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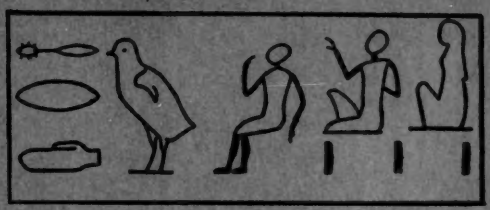
# CHILD DEVELOPMENT





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NATIONAL RESEARCH COUNCIL
2101 CONSTITUTION AVENUE
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# THE MEASUREMENT OF DOMINATION AND OF SOCIALLY INTEGRATIVE BEHAVIOR IN TEACHERS' CONTACTS WITH CHILDREN

HAROLD H. ANDERSON[1]

This study reports the extension into adult-child relationships of measures of domination and of socially integrative behavior that were developed in previous studies of the interplay of preschool children.[2]

What is dominative behavior? And what behavior is socially integrative? The terms in the title of this paper are merely convenient labels for two techniques of behaving that have been experimentally demonstrated to be psychologically different. In the initial investigations it was assumed for example that there is a psychological difference between snatching a toy out of a companion's hands so as to play with it oneself and asking the companion if one may borrow the toy for awhile. It was assumed that there is a psychological difference between a command and a request, between "tellin' 'em" and "eskin' 'em."

The use of force, commands, threats, shame, blame, attacks against the personal status of an individual are called dominative techniques of responding to others. Domination is characterized by a rigidity or inflexibility of purpose, by an unwillingness to admit the contribution of another's experience, desires, purposes or judgment in the determining of goals which concern others. Domination is behavior that is based on a failure to admit the psychological inevitability of individual differences. Domination stiffles differences; domination attempts to make others behave according to one's own standards or purposes. Domination obstructs the natural growth processes of further differentiation through the interplay of existing differences. Domination is, therefore, antagonistic to a concept of growth. Domination is consistent with a concept of self-protection. But growth is self-abandoning; it is a giving up of the present structure or function, a yielding of present concepts, standards or values for new structures, functions, concepts, standards or values that are in process of emerging. Self-preserving, however necessary it may be under circumstances of extreme insecurity, is something decidedly less than growth at its optimum. Domination may therefore be said to be the behavior of a person so insecure that he has to be self-protective rather than self-abandoning, that he has to maintain a status quo rather than voluntarily enter and participate in a changing situation. Domination involves force or threats of force or of some other form of the expenditure of energy against another. Domination is behavior of one who is so insecure that he is not free to utilize new data, new information, new experience. Domination is an attempt at atomistic living; the desires, purposes, standards, values, judgment, welfare of others do not count; it is rugged individualism of a highly ingrowing order. Domination is the antithesis of the scientific attitude; it is an expression of resistance against change; it is consistent with bigotry and with autocracy. It is the technique of a dictatorship.

If, instead of compelling the companion to do as one says, one asks the companion and by explanation makes the request meaningful to the other so that the other can voluntarily cooperate, such behavior is said to be an expression not so much of pursuing one's own unique purposes as attempting to discover and get satisfactions through common purposes. For such expenditure of energy in common

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[2]*Anderson, Harold H.: An experimental study of dominative and integrative behavior in children of preschool age. J. Soc. Psychol., 1937, 8, 335-345.*
*Anderson, Harold H.: Domination and integration in the social behavior of young children in an experimental play situation. Genet. Psychol. Monog., 1937, 19, 341-408.*

purposes, for an attempt to reduce instead of augment or incite conflict of differences the term integrative behavior is used. The person who can change his mind when confronted with new evidence which has grown out of the experience of another is said to be integrating differences. Integrative behavior as the term is used here is consistent with the scientific point of view, the objective approach. It designates behavior that is flexible, growing, learning.

The term integration is not used here as it has been used by some in contrast with differentiation. It is believed that the two processes are inseparable and are merely different aspects of the same psychological or biological phenomenon. With the integration of differences something new is created that never has existed before; this emergence of originals through the integration of differences is itself a differentiation.

Integrative behavior is thus consistent with concepts of growth and learning. It makes allowance in one's own behavior for differences in others. It is behavior that makes the most of individual differences. Whereas domination stifles or frustrates individual differences, socially integrative behavior respects differences, advances the psychological processes of differentiation. Integrative behavior is flexible, adaptive, objective, scientific. It is an expression of the operation of democratic processes.

In addition to the assumption that domination and integration are psychologically different techniques of responding to others another assumption advanced at the outset in the experimental program was that domination and integration would offer different predictions of subsequent behavior. Both in the previously published research on the behavior of preschool children and in a recent study of domination and integration in the behavior of kindergarten children[3] data have offered only consistent evidence in support of the hypotheses that:

1. Domination incites resistance, which is itself dominative.
2. Integrative behavior induces cooperation or integrative behavior in a companion.
3. Domination is not only different from, but where a potential avenue of escape is left open, it is dynamically unrelated to integrative behavior.

It should be pointed out that there is no relationship short of the extermination of another individual that is entirely dominative and no situation in which the interplay is entirely integrative. But many situations arise in which the techniques of responding to others can be reliably said to be expressions of domination or of integrative behavior.

Aims. The purpose of the present study was to develop reliable techniques for recording in terms of dominative and integrative behavior the contacts which teachers have with kindergarten children.

Methods and procedure. It was expected at first that an experimental situation would need to be devised but it was shortly discovered that the teachers' contacts both with individual children and with the group occurred with such rapidity as occasionally to tax the abilities of the observers to record them.

With criteria already experimentally established for recording in terms of domination and integration social contacts of paired preschool and kindergarten children with each other it still was not easy to adapt these criteria to the contacts which teachers had with children. Preliminary observations were made in a number of different schools. The teachers were for the most part soft-spoken, attentive, patient; and considerate of the children. In a number of rooms there appeared to be a complete absence of commands or of other evidence of obvious domination in the teachers' responses to children. Teachers, to be

[3] *Anderson, Harold H.: Domination and integration in the social behavior of kindergarten children in an experimental play situation. Unpublished study reported in part in paper of same title read at the meetings of the Midwestern Psychological Association, University of Nebraska, Lincoln, Nebraska, May 5, 1939.*

sure, told children to do certain things and not to do other things. But all teachers do that. To do so in a casual sympathetic way may seem an inherent part of schoolroom procedure. The whole school curriculum is in a sense a systematic statement of environmental demands to be made on the child.

If a teacher in introducing the music period said, "I am going to sing you a song," it was felt that that was definitely a social contact with the group, and as such should be recorded. It was not clear at first whether it could be checked as dominative or integrative nor was it clear what difference it made what one called the contact. It was with much labor that the experimenters were able to devise criteria and arrive at definitions that would record reliably domination even if expressed in a "soft voice." It seemed that a key to the difficulty could be found by checking the teachers' remarks against the criteria of conformity by the child versus joint participation by the child or by the group. Did the teacher tell them or ask them? Did she base decisions on her own desires or judgment or did she allow some measure of interplay for the child's desires, the child's judgment?

It did seem as though for each isolated remark it made little difference whether the teacher told them that she was going to sing a song or asked them whether they would like a song or, if so, what song would they like to hear? It seemed logical to expect, however, that an accumulation of tallies that would record such simple differences would make a distinction between some teachers and others, that in some schoolrooms there would be a great deal or a preponderance of teachers' contacts in which the teacher told the children what to do, what she was going to do, or what the activities were to be. And on the other hand, it was conceivable that other teachers would have much lower frequencies of such techniques and might perhaps be found to be giving the pupils a proportionately higher number of opportunities to use their own judgments.

Domination in the present study includes social contacts in which the activity of the child or of the group is determined out of the experience or judgment of the teacher. Such a contact is psychologically different from the contact in which there is a democratic interplay, in which the determination of the child's activity comes from a broader experiental base that includes the judgment or choices of the child himself. The psychological assumptions are that the child "learns" less arithmetic if father does all his problems for him, and he grows less in other respects to the extent that the teacher decides what is to be done and how and when to do it. Telling them is assumed to be not only psychologically different from asking them, but in general it is assumed to be less propitious for growth, learning, and problem-solving.

The observation blank. An observation blank was devised to contain five minutes of observations. Each blank bore the identifying information showing the school, grade, section, date, observer and teacher and in addition the name of the activity in which the group was engaged, the time the observation period began and ended and the elapsed time of the observation period. The blank which was adopted after experimentation with two other forms is shown in Figure 1. It had the names of the children at the tops of vertical columns and the names of the categories of teacher contacts on the horizontal rows. The categories were arbitrarily defined for convenience in recording. It will be noted that there are no categories for numbers 11 to 14 inclusive. These numbers designated categories on previous experimental forms of the observation blank which were finally combined with other categories. Because the experimenters had memorized the other categories by number and by relative position on the blank, the numbers and original spacing were retained on the final observation blank. For aid in recording categories quickly two additional columns of guide numbers were inserted in the blank.

The schoolroom situation. From eight different kindergarten groups from

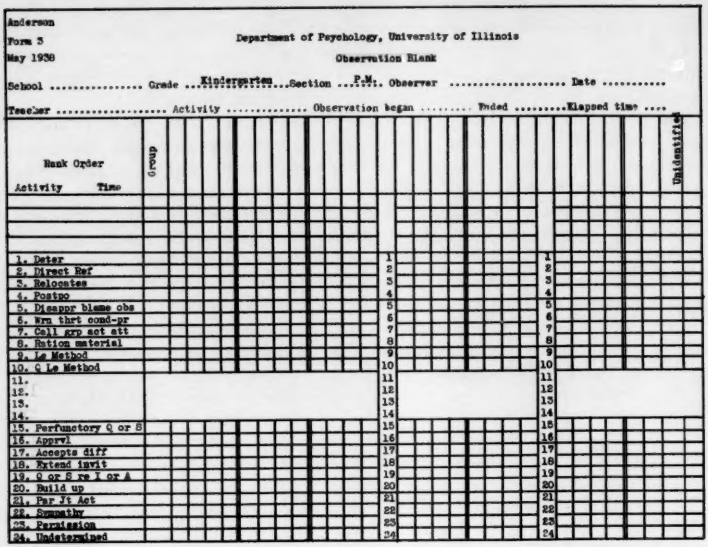


FIGURE 1

which data have been gathered findings are presented here for three groups: morning and afternoon groups of children from school X, both groups taught by teacher A and B; and a morning group from school Y taught by teacher C. In school X the head teacher, teacher A, took the leading rôle with the children much more frequently than did the assistant teacher, teacher B. The assistant had charge of the music period during which time most of the contacts of teacher B which entered the data were recorded.

Methods of observation. The observers were instructed to observe the teacher who was playing the major rôle with the children. The frequencies of teacher contacts thus represent those of the one teacher most active at the time but by no means all the contacts which the children received from both teachers during the observation period.

The observer marked the blank by placing in the child's column one tally for each contact which the teacher had with that child individually. If the contact was directed to the group rather than to an individual the tally was recorded in the "Group" column.

If the teacher made some contact with a child or with the group, but the nature of the contact was not clear, the observer recorded a tally under category 24, "Undetermined." If the nature of the category was clear, but it was not known with whom the contact was made, the tally was placed in the "Unidentified" column at the right-hand side of the blank. This column collected not only a few contacts which occurred when the observer for one reason or another failed to see or to hear, but a number of such partially disguised contacts as "Some little boy forgot to remember what we said about hands - or eyes - or feet."

Subjects. The subjects were fifty-five kindergarten children attending three groups. In general the children were superior in intelligence. In school X an attempt had been made to enroll younger children in the morning group. The enrollment in school X was twenty-three in the morning group, twenty-one in the afternoon group and in school Y, eleven. In the three groups the girls had the

respective numerical superiority of three, three and one as compared to the numbers of boys.

Definitions of the categories. The full titles of the categories together with examples of teachers' contacts which they include are given below. Actual observations of teachers' behavior constituted the basis on which each category was constructed and defined.

Categories 1 to 8 inclusive record dominative contacts of the teacher. Categories 15 to 23 inclusive record the teacher's integrative contacts. Categories 9 and 10 which had low frequencies were regarded as ambiguous hybrids, not clearly classifiable as domination or integration. It is believed, however, that the majority of contacts checked in category 9 belong more properly in the group of dominative techniques, and that contacts checked in category 10 would fall more properly among the integrative contacts.

The establishing of categories was an arbitrary matter of convenience in recording the teachers' contacts and also a means for a preliminary search for more refined analyses of teachers' behavior. Analyses of the data have been made to show the consistency with which two independent observers recording simultaneously were able to record teachers' contacts by categories. But in the treatment of the data to show the contacts of the teachers with the individual children and with the group all the dominative and all the integrative categories respectively are combined.

CATEGORIES

1. Determines a detail of activity or acts for the child in carrying out a detail.
   Includes instances where T (teacher), in order to rush through to an end, goes ahead and does things for the child.
   T: "You will have to fold yours like this."
   "We won't play that game any more."
2. Direct refusal.
   T: answers "No" to a direct request.
3. Relocating, reseating, or placing children in different relation to each other or to property, i.e., different from the relation which the children have themselves selected.
   T: "Henry, Janet, Sam, please sit down."
4. Postponing, slowing up the child.
   T: "Not now."
   "Wait just a minute."
   "Later on."
   Holds back the fast ones.
   Obstructs differentiation, originality, individual differences, variability within a group.
   T: "Betty Lou, go back and wait until I come around."
   "Wait at your place until I give you one."
5. Disapproval, blame, or obstruction.
   T: "Hurry up" implies disapproval.
   "I'm waiting."
   "One little boy - I don't see his eyes at all."
   Check "unidentified."
6. Warning, threats, or conditional promises.
   T: "I don't want to speak to Henry, Sam, and Janet again."
   "Now if we all sit nicely and keep our hands to ourselves, we might have two stories."
7. Call to attention or to group activity.
   Call to attention during group activity.

T: "Girls and boys --------."
T: "Let's see who is listening."

8. Rations material.
T. makes decisions as to amount, kind, etc.. e.g. amount of paste, amount of grass for rabbit nests.
(Implication is that rationing of materials is psychologically more than an administrative convenience; it deprives the child of an opportunity to exercise his own judgment, to decide for himself how much it will take for the job at hand; and for this reason it is an expression of T. domination).

9. Lecture method.
T. gratuitously defines a problem or anticipates the question and gives the answer. (The "sez you" category).
e.g. T., passing out paper:
T: "The paper is to keep the paste off the tables."
(If there was a problem of keeping the paste off the tables, the children might have contributed from their experience in defining the problem, especially since only the children got paste on the table. As a matter of fact, the tables were made so paste could be washed off. Paste actually got on the tables, and as a later part of the routine a child with great enthusiasm did wash the tables after the children were through pasting).
T: "You won't need your scissors." (check #9)
(But) "Don't get your scissors." (check #1)

10. Questions: Lecture method.
Questions where the answers are in the back of the book or in the teacher's experience.
T: "What did the birdie say?"
If there is only one answer, then check #10.
If the child is permitted to give an imaginative answer, then check under #19 or #20.

11-14 inclusive deleted on the blank.

15. Perfunctory question or statement.
Indifferent "Thank you's."
T: "Isn't that interesting?" - a bare response, but a response nevertheless.

16. Approval. Includes rewards, prizes, competitive favors.
T: "I think that's fine."
"Billy's row is standing the straightest."

17. Accepts difference.
Observer must be alert for negative votes, declinings, expressions of difference, conflicts of difference. Whenever T. makes an offer or gives an invitation, and the child declines, some category should be checked for T's response: She either accepts the difference (#17); or she reproves (#5); or she renews her request (#18).
e.g.
T: "Jimmy, would you like to sing this one (song) up here? (beside T.)" Jimmy declines.
T. turns to another child.
(Check rank order for Jimmy, #18, Extends invitation; check the other child, rank order for #18; check Jimmy for #17, Accepts difference).

18. Extends invitation to activity.
T: "Who wants to be a pony?"

"Who would like to be a robin?"

Call for a show of hands. The choice rests with the children. It must be obvious that there is no element of exhortation and that a child can still decline. Under few circumstances will an invitation be made more than twice without obvious attempts to exhort; in which case check #1. A teacher's contact in category #1 cannot be declined without further exhortation or disapproval.

19. Question or statement regarding child's expressed interest or activity.
Carries no presumption of opposition, antagonism, disapproval or urging.
"Dickie, are you waiting for paste?"
"How are you getting along?"
Includes the ice-breaker conversation.
"Do you have a dog at home?"

20. The build-up. Highly integrative behavior.
Includes instances where T. helps child to arrive at a better definition of a problem or a better solution, without giving the final answer.

21. Participates in joint activity with children.
Offers help, offers to participate.
Children playing ball. Ball rolls over near T. who returns it.

22. Sympathy.
T: "I'm sorry you hurt your finger."

23. Permission: T. grants permission to child's request.
e.g. "May I get a drink?"
"May I pass the cookies?"

Since a series of research studies into different age levels and different situations is contemplated, the problem of reliability of two observers became an end in itself. A more extended analysis was made of the difficulties in recording than would have been undertaken if the objectives had been merely to study these particular schoolrooms.

The observers attempted to record at an appropriate place on the blank every "contact" which the teacher had with an individual child or with the group during the period of observation.

How reliably could the observers identify instantly and record the contacts in individual categories? How accurately could they assign these contacts to individual children or to the group? Could two independent observers record at the same speed? Could they agree in their definitions of a contact or would they come out with greatly varying numbers of tallies? Could they observe and record the contacts of one teacher more reliably than they could the contacts of another teacher? Could they observe dominative contacts more reliably than integrative contacts? These were some of the questions that have been answered in the analysis of the data.

Seventy-three pairs of consecutive and simultaneous records of five minutes each by observers M and N were analyzed. All the tallies on each observation blank were totaled and these totals correlated for the two observers. Table 1 gives the coefficients of correlation for separate combinations of observation periods showing respectively contacts of teachers A and B combined for the morning and again for the afternoon, contacts of teacher A for the morning and afternoon combined, and likewise for teacher B, and contacts for all of the seventy-three periods combined.

These high coefficients indicate that as far as the speed of recording was in question there was virtual identity in relative number of tallies recorded per observation period. This consistency of speed is shown whether the observations are for one teacher or the other; or whether they are made during the morning activities or during the afternoon program. These coefficients show also a

TABLE 1

COEFFICIENTS OF CORRELATION BETWEEN OBSERVERS M AND N FOR TOTAL NUMBERS OF CONTACTS PER OBSERVATION PERIOD FOR SEVENTY-THREE OBSERVATION PERIODS

| Teacher | A & B | A & B | A | B | A & B |
|---|---|---|---|---|---|
| Session | A.M. | P.M. | A.M. and P.M. | A.M. and P.M. | A.M. and P.M. |
| r | .95 | .96 | .97 | .96 | .96 |
| $P.E._r$ | .01 | .01 | .01 | .01 | .01 |
| N. | 35 | 38 | 44 | 29 | 73 |

very high agreement between observers in using the definitions of a "teacher contact." Moreover, during these seventy-three periods covering five hours and forty-five minutes of simultaneous observation, observer M recorded 1,897 teacher contacts and observer N recorded 1,893.

Table 2 shows coefficients of correlation which indicate how reliably two observers recorded for individual children the dominative contacts, integrative contacts and total contacts of the teacher.

Ten coefficients of reliability of two observers for teachers' contacts with individual children for total numbers of contacts of all kinds were .87 or above, six of the ten being .94 or above.

Ten coefficients of reliability of observers for teachers' dominative contacts with individual children (categories 1-8) were .80 or above, six of the ten .93 or above.

The coefficients of reliability of observers of teachers' integrative contacts with individual children (categories 15-23) were based on lower frequencies and were low but consistently within a narrow range.

There was considerable evidence that in spite of the high degree of reliability of the two observers in recording total contacts of the teachers, the observers were at times unable to record the contacts at the speed with which they occurred. This would account in part for the lower coefficients of reliability for integrative contacts which by their nature must often be identified by their context, are therefore less specific and more difficult to record.

The most rigorous method of analyzing all the data for reliability of two observers in which teachers' contacts were correlated child by child and category

TABLE 2

COEFFICIENTS OF CONSISTENCY OF OBSERVERS FOR TEACHER CONTACTS PER CHILD WITH CATEGORIES GROUPED. (ONE TALLY ON THE SCATTER DIAGRAM REPRESENTS, e.g., TALLIES IN CATEGORIES 1-8 FOR ONE CHILD)

| School | Teachers | Session | Groups of categories: Total contacts 1-24 | | | Domination 1-8 | | | Integration 15-23 | | | Total time (min.) | Mean time of correlated periods (min.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | r | $PE_r$ | N | r | $PE_r$ | N | r | $PE_r$ | N | | |
| X | A & B | A.M. & P.M. | .94 | .00 | 688 | .93 | .00 | 574 | .46 | .03 | 271 | 342.5 | 4.69 |
| | A & B | A.M. | .94 | .01 | 319 | .94 | .01 | 259 | .44 | .05 | 111 | 155.5 | 4.44 |
| | A & B | P.M. | .94 | .00 | 369 | .93 | .01 | 315 | .46 | .04 | 160 | 187.0 | 4.92 |
| | A | A.M. & P.M. | .89 | .01 | 411 | .84 | .01 | 319 | .48 | .05 | 191 | 204.5 | 4.65 |
| | B | A.M. & P.M. | .96 | .00 | 277 | .95 | .00 | 255 | .50 | .06 | 80 | 138.0 | 4.76 |
| | A | A.M. | .87 | .01 | 197 | .87 | .01 | 148 | .53 | .05 | 91 | 99.5 | 4.52 |
| | B | A.M. | .97 | .00 | 122 | .97 | .00 | 111 | .10 | .23 | 20 | 56.0 | 4.30 |
| | A | P.M. | .91 | .01 | 214 | .80 | .02 | 171 | .44 | .06 | 100 | 105.0 | 4.77 |
| | B | P.M. | .96 | .01 | 155 | .94 | .01 | 144 | .53 | .06 | 60 | 82.0 | 5.13 |
| Y | C | A.M. | .89 | .01 | 131 | .87 | .02 | 114 | .29 | .08 | 66 | 65.0 | 5.00 |

by category showed for 1,560 squares on record blanks for school X a coefficient of .78; and for 378 squares on record blanks for school Y a coefficient of .77. These coefficients are sufficiently high to make the data in this study acceptable as measures of teachers' behavior.

Number of teachers' contacts per hour with individual children. The speed or rapidity with which teachers make contacts with children raises some pedagogical and mental hygiene questions. The complaint has often been made at home and at school that children are unable to concentrate, that they cannot carry on activities by themselves or hold to a given purpose without adult encouragement or stimulation. The complaint though frequently made is not very clearly formulated. Studies have been made of the attention span of preschool children and of others, but as yet there are no standards or criteria against which to evaluate either the performance of an individual child or that of a group. From experience in clinical psychology one has often suspected that children have been unnecessarily interrupted in their serious purposes by well-meaning adults. In some cases the "over-supervision" has been so unrelenting as to make it seem as though the child could do little or nothing by himself. In fact the greater amount of "free play" or freedom to inquire and to explore one's environment is one of the chief criteria by which the nursery school is distinguished from public school education.

But as to how much free play a child needs; how much supervision is a "good thing"; how many contacts with an adult a child should have; when supervision ceases and "over-supervision" begins; what mistakes and how many a child should be permitted to make without adult interference; - for answers to these questions there are only unreliable clinical generalizations. It is obvious that before one can speak reliably about "too much" he must first have units of measurement. This study constitutes an important first step in providing such units of measurement.

Table 3 shows the mean number of contacts per hour which each teacher had with individual children, the mean number of dominative and integrative contacts per hour and the total observation time in minutes on which are based the respective rates of contacts. The Domination-Integration ratio is obtained by dividing the mean number of domination contacts per hour by the mean number of integration contacts per hour.

It can be noted that the highest frequencies for all contacts for separate periods show for teacher A 421.3 contacts per hour; for teacher B 474.5 contacts per hour; and for teacher C 489.8 contacts per hour. When morning and afternoon contacts are added together and the means per hour per child computed, teachers A and B are nearer together in frequencies, showing respectively 401.3

TABLE 3

MEAN NUMBER OF INDIVIDUAL CONTACTS PER HOUR FOR TEACHERS A, B AND C

| | | | | | Categories | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | 1-24 | 1-8 | 15-23 | |
| School | Session | Teacher | Children | Total Obs. Time (min.) | Total contacts | Domination | Integration | D-I ratio |
| X | A.M. | A | 23 | 362.0 | 421.3 | 244.2 | 115.7 | 2.1 |
| | | B | 23 | 98.5 | 384.4 | 278.4 | 55.4 | 5.0 |
| | P.M. | A | 21 | 352.5 | 380.8 | 210.4 | 97.5 | 2.2 |
| | | B | 21 | 109.0 | 474.5 | 350.6 | 71.6 | 4.9 |
| | A.M. and | (A | | 714.5 | 401.3 | 227.5 | 106.9 | 2.1 |
| | P.M. | (B | | 207.5 | 431.7 | 316.3 | 63.9 | 4.9 |
| Y | A.M. | C | 11 | 440.5 | 489.8 | 292.4 | 126.3 | 2.3 |

and 431.7 contacts per hour. This represents for teacher A a rate of 6.7 contacts per minute for 11.9 hours of observation and for teacher B a rate of 7.2 contacts per minute over a period of 3.5 hours of observation, with the presumption in both cases that a considerable though undetermined number of contacts were unrecorded.

Another pedagogical as well as psychological problem is presented in the comparison of the teacher in school Y with the teachers in school X. There were twenty-three children enrolled in the morning session of school X and twenty-one enrolled for the afternoon. In school Y, however, there were only eleven children present during the period of observation for this study. It can be seen in Table 3 that for teacher C there are no great proportional divergences in frequencies of contacts as compared with the frequencies for teachers A and B who had larger groups of children. It can be noted that the rates of integrative contacts and of total numbers of contacts of teacher C exceed in all cases the rates for the teachers in school X while the rate of dominative contacts of teacher C exceeds all rates except for teacher B for the afternoon and for the combination of morning and afternoon.

Is one to draw an inference that teachers are themselves responding at a "capacity rate" whether they have one dozen or two dozen children in the room? Or stated in another way do teachers regardless of numbers of children before them respond at a fairly constant rate? These data raise a further question as to how many children constitute a teacher load. Were the children in school Y receiving twice as much "teaching" as the children in school X? The data show that the children in school Y had almost twice as many individual contacts per hour as did the children in school X. Again the question as to how many contacts are desirable pedagogically and psychologically must remain unanswered. All that can be said here is that in this study measures have been developed that indicate considerable differences in teachers' techniques.

It may be noted in Table 3 that in all cases the dominative contacts outnumber the integrative contacts by at least two to one and that in one case the ratio of domination to integration contacts is five to one. The contrast between teachers' dominative contacts and integrative contacts is shown graphically in Figure 2 which gives the respective frequencies per hour for individual teachers.

Five groups of data offered in Table 3 have been broken down to show the frequencies of contacts per hour which teachers had with individual children. These data are presented graphically in Figures 3 to 7 inclusive. Figures 3 and 4 show respectively for teachers A and B the mean number of contacts per hour which they had with each child enrolled in the morning group. A glance at these figures shows that as far as can be indicated by the frequency of the teacher's contacts per hour the individual children in this kindergarten live at school in different environments.

Figure 3 shows a range of total contacts of from 4.1 to 39.3 per hour, with the median child receiving 13.2 contacts per hour. The median child thus received about three times as many contacts per hour as the child lowest in rank and only about one-third the frequency of that of the highest child in rank order. The child at the top of the rank order received almost fifty per cent more contacts than the child who was next in rank.

The frequencies of dominative contacts show a range of 3.2 to 24.9 with the median at 6.5 dominative contacts per hour. The rank orders show generally small differences from child to child from the bottom of the list up to the fifth ranking child. The fourth child in rank, however, is about fifty per cent above the fifth in rank or almost twice the median.

The range of integration frequencies is from 0.7 to 10.7 contacts per hour with the median at 4.5. From Figure 3 it can be seen that the curve for integra-

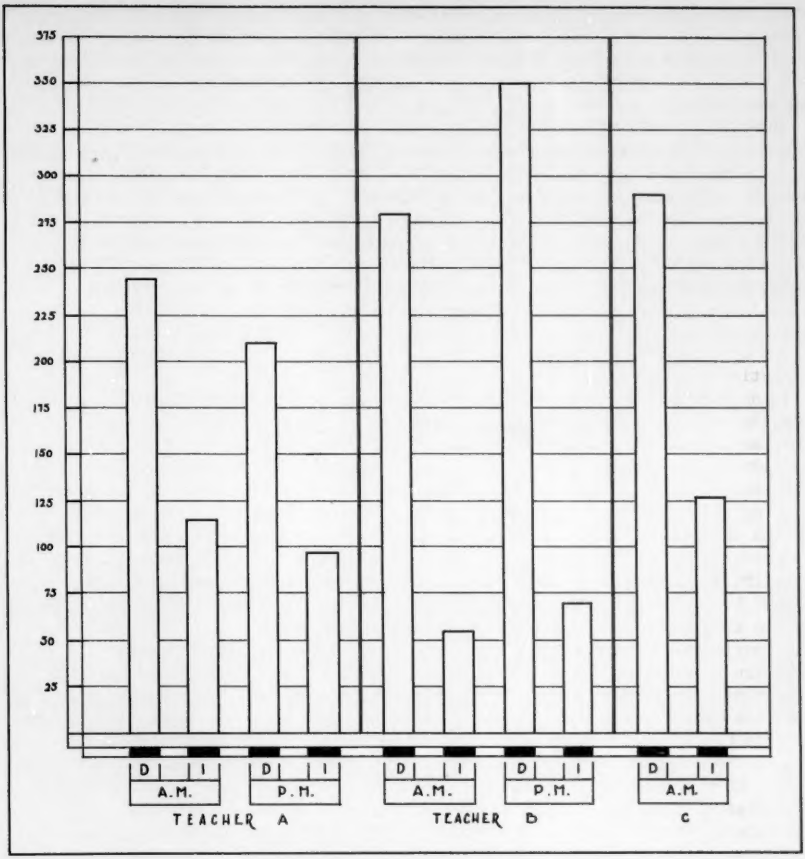


Fig. 2. Mean number of dominative and integrative contacts per hour which teachers A, B and C respectively had with individual children.

tive contacts not only extends within a shorter range than the curve for domination contacts but that, excepting the cases of three individual children, the integration curve lies below the domination curve. For these three children the Domination-Integration ratios become less than one.

The Domination-Integration ratios for the children represented in Figure 3 range from 0.6 to 4.6. It can be noticed that the child with highest D-I ratio is the child who had the lowest total number of contacts per hour with the teacher. In acticipation of further research it may be asked: Is this child to be regarded as "pedagogically self-sufficient" or merely neglected? Or what does it mean to a kindergarten boy whose frequency of total contacts with the teacher is relatively "negligible" to have four out of five of those contacts of a dominative character?

Figure 4 shows the contacts per hour which teacher B had with individual

children in the morning session. In comparison with the contacts of teacher A in Figure 3 it can be seen that teacher B had much lower frequencies of integrative contacts; with six children she had none. The ranges of dominative, integrative and of total contacts, however, are about the same for teacher B as for teacher A.

Figures 5 and 6 show respectively for teachers A and B the individual contacts per hour which these teachers had with the children enrolled in the afternoon group. Although the children in this group were older the curves show ranges, medians and tendencies toward individual differences similar to the curves for the contacts with the children enrolled in the morning group.

A contrast is shown, however, in Figure 7 which represents graphically the contacts per hour which teacher C had with eleven children. In general, the children with teacher C, numbering approximately half those with teacher A, received mean numbers of contacts per hour not quite double the frequencies of those with teacher A.

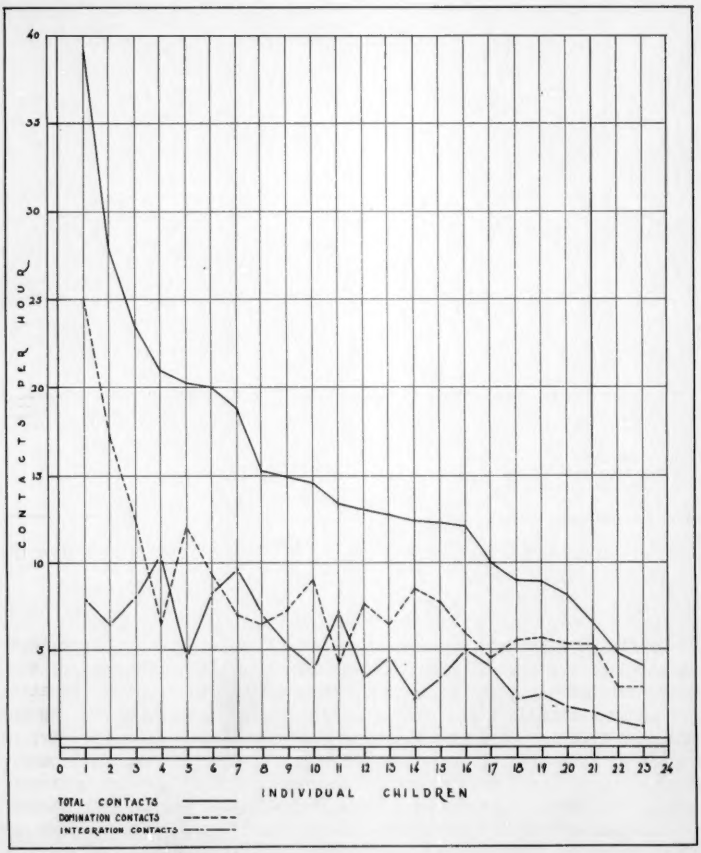


Fig. 3. Mean number of contacts per hour which teacher A had with individual children enrolled in the morning session.

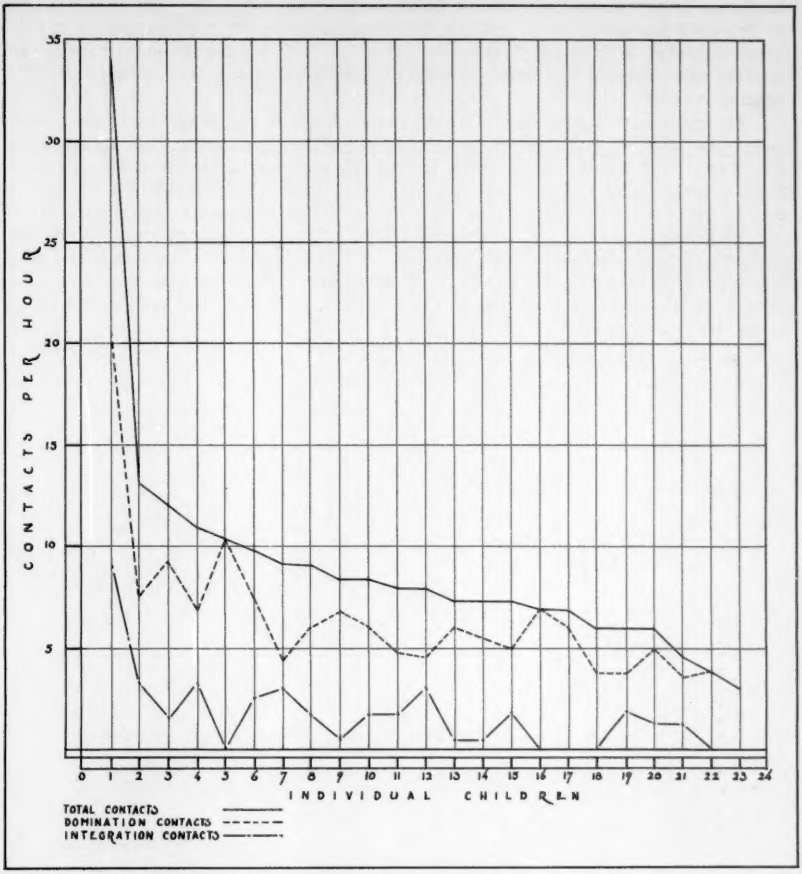


Fig. 4. Mean number of contacts per hour which teacher B had with individual children enrolled in the morning session.

The striking contrasts between teacher C and teachers A and B suggest that an extension of the present research techniques to the measurement of the behavior of teachers in a larger number of schoolrooms selected for greater control of known variables would have important theoretical value for the psychology of human relations and practical value for educators and mental hygienists.

Number of teachers' group contacts per hour. The contrasts and comparisons given in Figures 5 to 7 inclusive represent the teachers' direct contacts with individual children. In addition to the frequencies represented on those graphs there were many contacts which the teachers had with the children as a group. The frequencies of these group contacts per hour are shown in Table 4.

It can be seen in Table 4 that teacher B had approximately twice as many group contacts of all kinds, categories 1-24, per hour of observation as did

teacher A, both for morning and for afternoon. When the data for total numbers of contacts for teachers A and B are combined, the new mean is not greatly in excess of the mean shown by teacher C.

With group contacts as with individual contacts domination exceeds integration. The range of D-I ratios in Table 4 is from 5.4 to 11.4.

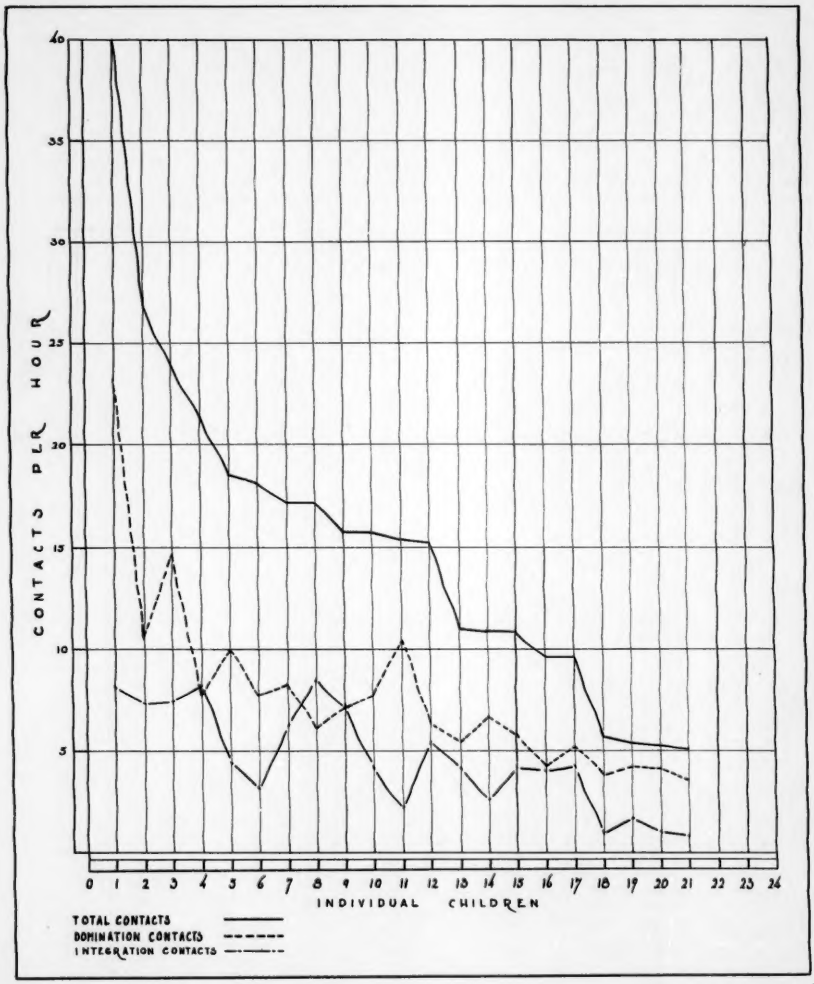


Fig. 5. Mean number of contacts per hour which teacher A had with individual children enrolled in the afternoon session.

TABLE 4

FREQUENCIES PER HOUR OF TEACHERS' GROUP CONTACTS

| School | Session | Teacher | Total Obs. Time (min.) | Categories 1-24 Total contacts | 1-8 Domination | 15-23 Integration | D-I ratio |
|---|---|---|---|---|---|---|---|
| X | A.M. | A & B | 460.5 | 112.6 | 80.7 | 11.5 | 7.0 |
| | | A | 362.0 | 93.0 | 65.5 | 10.0 | 6.6 |
| | | B | 98.5 | 184.6 | 136.5 | 17.1 | 8.0 |
| | P.M. | A & B | 461.5 | 106.5 | 80.4 | 9.9 | 8.1 |
| | | A | 352.5 | 84.1 | 60.4 | 9.0 | 6.7 |
| | | B | 109.0 | 178.9 | 144.8 | 12.7 | 11.4 |
| Y | A.M. | C | 440.5 | 105.8 | 64.4 | 12.0 | 5.4 |

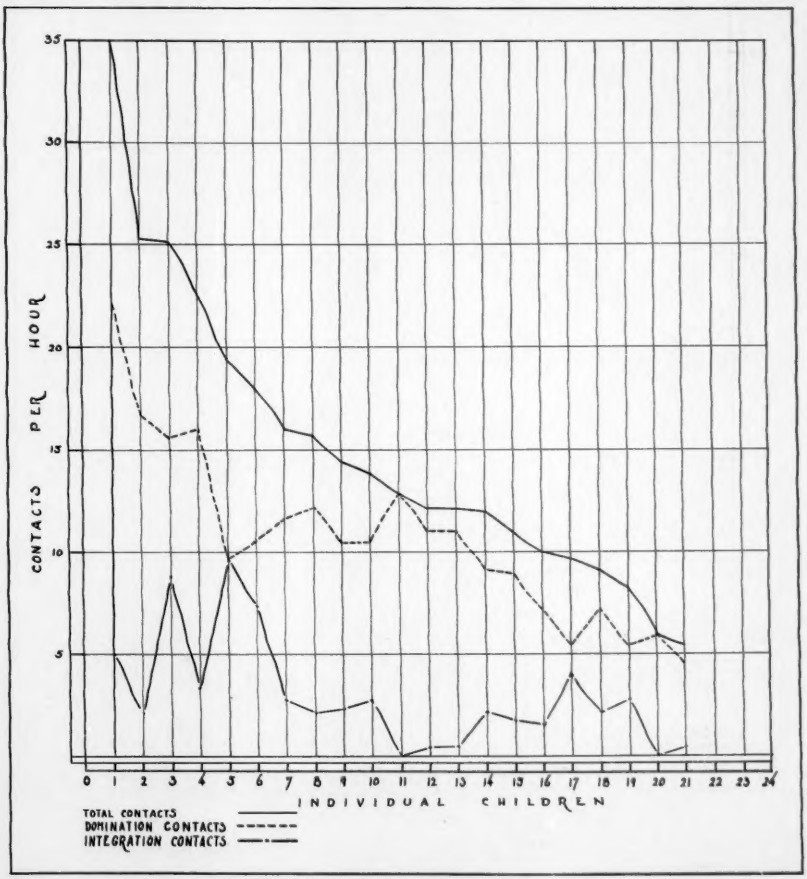


Fig. 6. Mean number of contacts per hour which teacher B had with individual children enrolled in the afternoon session.

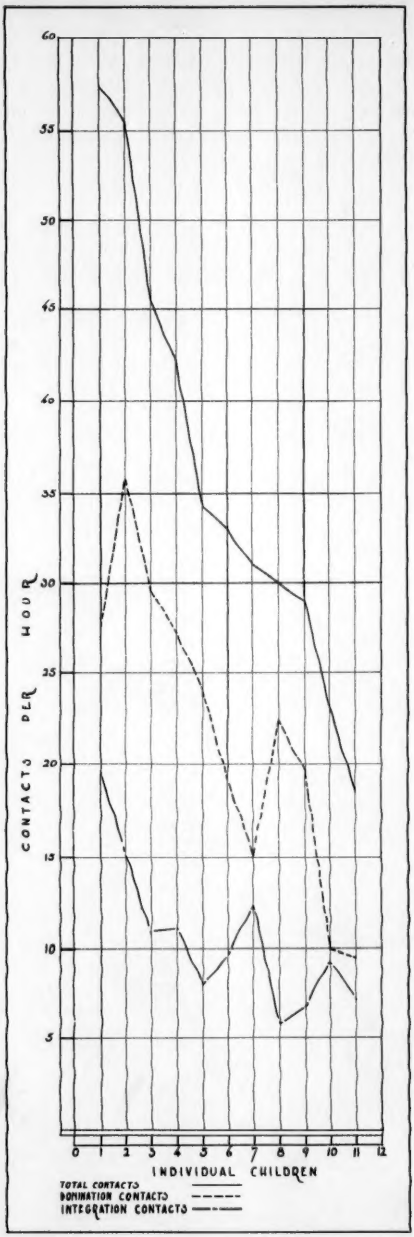


Fig. 7. Mean number of contacts which teacher C had with individual children.

SUMMARY

Domination is the behavior of a person who is inflexible, rigid, deterministic, who disregards the desires or judgment of others, who himself in the conflict of differences has the answers. Examples are the use of force, commands, threats, shame, blame, attacks against the personal status of another. Domination is the technique of autocracy or dictatorship; it obstructs the growth processes in others. It is the antithesis of the scientific attitude and the open mind.

The term integrative behavior was chosen to designate behavior leading to a oneness or commonness of purpose among differences. It is the behavior of a flexible growing person who is looking for new meanings, greater understandings in his contacts with others. It is non-coercive; it is the expression of one who attempts to understand others, who is open to new data. It is consistent with the scientific approach, the open mind. It is both an expression of growth in the person using it and a stimulus to growth in others. It does not stifle differences, it makes the most of differences; it actually creates new and harmonious differences.

No behavior is entirely integrative; none short of extermination is entirely dominative, but in the interplay of differences specific acts or contacts can be reliably said to be expressions of domination or of integrative behavior.

The purpose of this study was to develop reliable measures for recording in terms of dominative and integrative behavior the contacts which teachers have with kindergarten children.

Three kindergarten groups in two schools taught by three teachers supplied the final data.

Reliability coefficients were established by data from seventy-three pairs of consecutive and simultaneous records of five minutes each by two independent observers. The observers showed high agreement in defining a contact, in recording the total number of contacts as well as in recording contacts per five-minute period. They were more reliable in observing dominative contacts than integrative contacts.

The number of contacts per hour were computed for contacts with individual children and contacts with the group.

In individual contacts teachers A and C each had twice as many dominative as integrative contacts and teacher B had five times as many dominative as integrative contacts.

In group contacts the ratios were higher, all being over five to one for domination.

Teacher C had less than half as many children as teachers A and B, yet had more individual contacts per hour per child. It cannot be said that these frequencies are "too high," for there are no norms or standards. Questions were raised as to what constitutes a teacher load.

During several hours of observation some children had almost no individual contacts with the teacher; others had averages as high as fifty-five contacts per hour.

# THE GROWTH OF THE LONG BONES IN 80 INFANTS

## ROENTGENOGRAMS VERSUS ANTHROPOMETRY

MARION M. MARESH and JEAN DEMING[1]

The growth studies in early infancy reported in the literature have been largely confined to anthropometric data. The present study was undertaken to present another method of estimating the rate of the growth process, by measurements of long bones from repeated roentgenograms.[2] One method was checked against the other by using both methods on the same children.

### MATERIAL

The children measured for this study were consecutive newborn infants at the Florence Crittenton Home in Denver. The data used were on those children who remained in the Home for 12 weeks or longer after birth. This group of 80 included 39 boys and 41 girls. The mothers of these children were in good physical health although 3 were classified as morons and 2 more were "mentally dull." Six had 4+ Wassermann reactions but had antiluetic treatment during pregnancy. The mean age of the mothers at time of delivery was just under 20 years. They were all first pregnancies with one exception. Since no sex difference was found in this small group, the data on boys and girls were combined and gave a mean birth weight of 6.96 pounds and a mean body length of 48.29 cm. at birth. Two sets of twins were included. The nationality was mixed. Forty-five children had American parents, 10 Spanish parents, and 2 Negro parents. The other nationalities included Italian, German, Swedish, Austrian, Mexican, and American mixtures. One child had a 3+ Wassermann at 3 months. All others had negative Wassermann reactions. The children were all partially breast fed with evaporated milk formulae as supplementary feedings. Cod liver oil was started by six weeks of age in amounts from 1 to 2 teaspoonfuls daily. The infants were all in good health during their stay at Crittenton Home although case #458 regurgitated a great deal of her food and failed to gain weight satisfactorily; and case #407 was thought to be mentally retarded. The mean weight gain for the group was 6 ounces per week.

The children were measured and roentgenograms were taken on the same day. Examinations were at approximately 6 weeks' intervals and no data were used unless a child had had at least 3 examinations. All measurements - anthropometric and X-ray - were made by one person (M.M.). Of the group of 80, 46 had 3 examinations each, 17 had 4 examinations, 14 had 5 examinations, and 3 had 6 examinations. On 71 of the cases measurements were begun during the first two weeks of life. Some of the infants who were in the Home at the time this study was begun were included and their initial examinations were at ages 6 to 21 weeks. Ages were approximated to the nearest week in all cases.

### METHOD

Fairly complete anthropometric records were made, using the technique of Scammon and Boyd. The left side of the body was used in all length measurements. Roentgenograms were made with the child lying supine on a 14 x 17 inch cassette on the floor with the X-ray tube 5 feet above the child. One assistant held the child's forearms flat on the cassette by holding the fingers and another assistant held a muslin band firmly across the knees, exerting enough pressure to extend the knees. Since no method could be devised for keeping the

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[2] *The authors wish to acknowledge their indebtedness to Dr. Karin Aileen Petri for her help and advice at the beginning of this study.*

shoulder in close contact with the cassette, films were taken when it was felt that the child had relaxed sufficiently to give a fairly accurate roentgenogram of the upper arm. Films were taken at 1/10 second and 75 MA with KV varying from 60 to 70 depending on the size of the child. After 6 weeks of age it was often necessary to take two films - one of the trunk and upper extremities and one of the lower extremities and pelvis. Distortion due to object-film distance was thus kept at a minimum, and since conditions were standard throughout, measurements made from these roentgenograms were used without correction. The greatest length of the left humerus, radius, ulna, femur, tibia, and fibula was measured to the nearest half millimeter on each film with a Lufkin steel ruler graduated to half millimeters. (Fig. 1.)

Many more anthropometric measurements were made than are used in this study. Since we were trying to check the accuracy of one method against the other, only those anthropometric measurements which correspond to the bone lengths were used in the calculations. These were acromio-radiale, radio-stylion, trochantero-

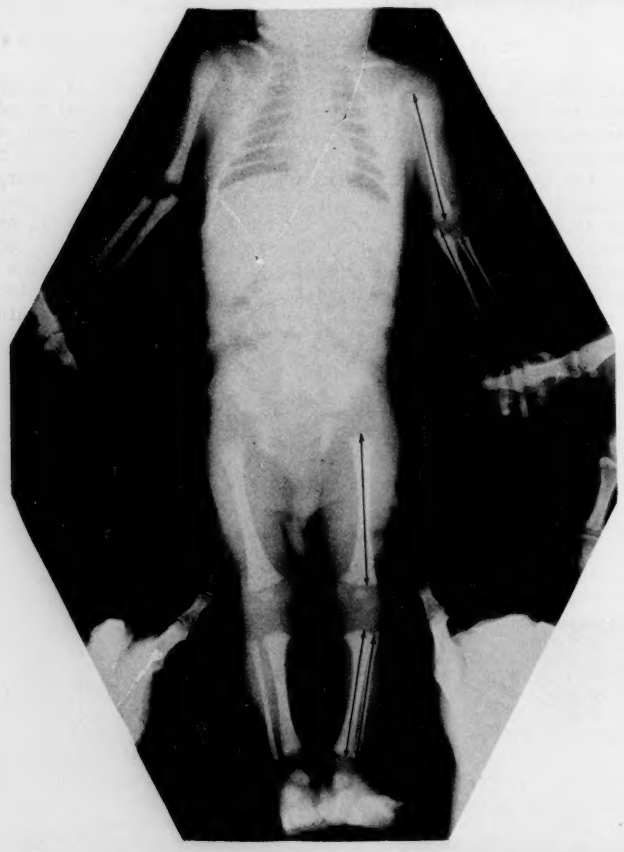

**Fig. 1. Sample roentgenogram used in this study illustrating the bone lengths measured.**

genu, and genu-malleolus. It was, therefore, necessary to use the radio-stylion measurement for comparison with both radius and ulna lengths and the genu-malleolus measurement for comparison with the tibia and fibula.

STATISTICAL TERMS USED

Mean ($\underline{m}$) $= \frac{\Sigma X}{n}$

Standard deviation ($\underline{\sigma}$) $= \sqrt{\frac{\Sigma x}{n} - m^2}$

Coefficient of correlation ($\underline{r}$) $= \frac{\frac{\Sigma xy}{n} - (m_x m_y)}{\sigma_x \sigma_y}$

Rate of growth in cm. per week ($\underline{b}$) $= r \frac{\sigma_y}{\sigma_x}$

Straight line calculated by method of least squares: $\underline{y} = \underline{a} + \underline{b}x$

Calculated birth value of any measurement ($\underline{a}$) $= m_y - b m_x$

Deviation of actual measurements about the calculated line ($\underline{\sigma_{y.x}}$) $= \pm \sigma_y \sqrt{1 - r^2}$

DISCUSSION OF RATES OF GROWTH AS SHOWN BY X-RAY AND ANTHROPOMETRIC MEASUREMENTS

The individual X-ray measurements on each child gave values which indicated uniform rate of growth during the period under consideration. Graphing these measurements against age in weeks gave essentially straight-line growth for all bones. Only two bones are illustrated (Figs. 2a, 2b, 3a, 3b), the femur, which is the most rapidly growing bone of the six long bones measured, and the radius, which is the slowest growing bone of the six long bones measured. Not only does growth proceed in a straight line during the first six months of life, but the lines for different individuals are very nearly parallel. A baby with a short femur at birth does not have a more rapid rate of growth than a baby with a longer femur. Thus a child tends to stay in his relative position within the


Fig. 2a. The successive femur measurements on 41 girls are plotted against age in weeks. The dots representing the individual femur lengths for each child are connected.

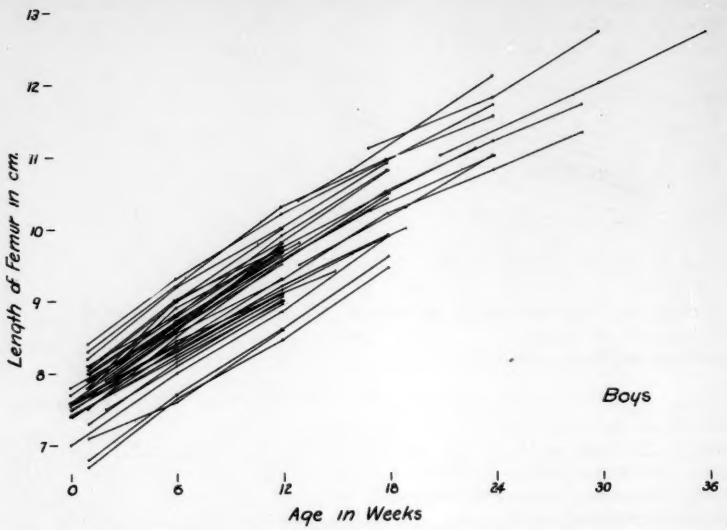


Fig. 2b. The successive femur measurements on 39 boys are plotted against age in weeks. The dots representing the individual femur lengths for each child are connected.

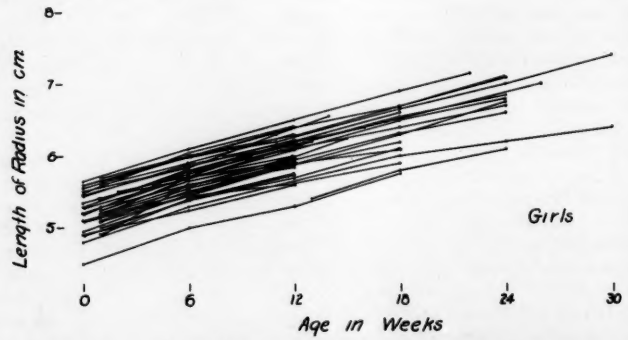


Fig. 3a. The successive radius measurements on 41 girls are plotted against age in weeks. The dots representing the individual radius lengths for each child are connected.

group during the first six months of life as regards the length of his bones. We hope to be able to determine subsequently whether this is true for the later periods of infancy and childhood. A similar program of X-ray measurement of long bones is now in progress for the group of children who are being followed from birth to maturity by the Child Research Council.

The mean rates of growth in centimeters per week (b) as calculated from the anthropometric measurements were comparable with the mean rates of growth calculated from the corresponding X-ray measurements. In each case, the standard

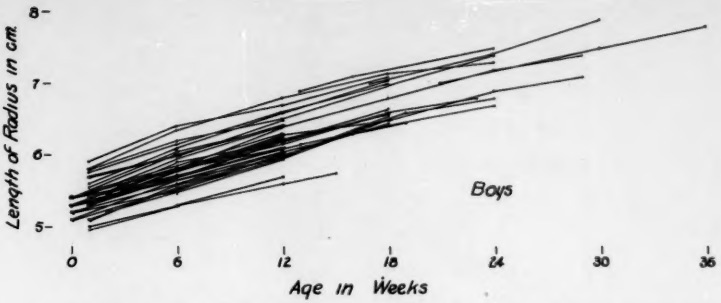


Fig. 3b. The successive radius measurements on 39 boys are plotted against age in weeks. The dots representing the individual radius lengths for each child are connected.

deviation was much greater for the values obtained from the anthropometric measurements. The high standard deviation is partly due to the fact that in 11 instances, the series of 3 anthropometric measurements gave no evidence of growth. In these instances, b was classified as having a value of zero. The mean coefficients of correlation (r) between the anthropometric measurements and age in weeks were not as high as the corresponding coefficients of correlation calculated from the X-ray measurements. Here again the standard deviations were greater for the values obtained from the anthropometric measurements. The mean deviation ($\sigma y.x$) of the actual measurements about the calculated line representing growth was considerably greater for the anthropometric measurements than for the X-ray measurements. For the anthropometric measurements this mean deviation varied from 0.2 to 0.3 cm. For the X-ray measurements, the mean deviation did not exceed the limits of accuracy of measurement (0.05 cm.) for any bone except the humerus. Mean values for each of these statistical constants are given in Table 1.

For the individual child, our findings indicate that the X-ray method of measurement is, in most instances, more accurate than the anthropometric method. The calculated rates of growth obtained from the two methods of measurement are approximately the same in some cases and in others are markedly different. Fig. 4 illustrates the growth of the femur and radius with their corresponding anthropometric measurements in 12 cases which were selected as fair samples of the entire group. It will be observed that in almost every case the deviation about the calculated line representing growth in length against age is much greater with the anthropometric measurements than with the X-ray measurements; and also that there is much less variation in the rates of growth calculated from the X-ray measurements than in those from the anthropometric measurements.

Since the mean values for rates of growth in centimeters per week were comparable with the two methods, it might be expected that the pairs of individual values for b would show good correlation. However, our calculated coefficients of correlation for the two types of measuring were poor, ranging from 0.191 to 0.536. We felt this was due to the unreliability of the individual anthropometric values for b.

There was some question as to whether a series of three measurements were sufficient for calculating a rate of growth. Therefore, we calculated coefficients of correlation between the pairs of individual values for b, using only the 34 cases who had had 4 or more examinations each. This showed no better correlation than when we used the entire group of 80.

TABLE 1

MEAN VALUES FOR CERTAIN STATISTICAL CONSTANTS RELATING TO GROWTH IN LENGTH WITH INCREASING AGE AS CALCULATED FROM MEASUREMENTS OF ROENTGENOGRAMS AND THE CORRESPONDING ANTHROPOMETRIC MEASUREMENTS ON 80 INFANTS

| X-RAY | | | | | | | | ANTHROPOMETRY | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bone | $r$ | | $b$ | | $\sigma_{y.x}$ | | | Measurement | $r$ | | $b$ | | $\sigma_{y.x}$ | | |
| | Mean | $\sigma$ | Mean | $\sigma$ | Mean | $\sigma$ | | | Mean | $\sigma$ | Mean | $\sigma$ | Mean | $\sigma$ | |
| Femur n = 80 | 0.997 | 0.004 | 0.150 | 0.017 | 0.056 | 0.049 | | Trochantero-genu n = 80 | 0.864 | 0.204 | 0.134 | 0.056 | 0.308 n=79 | 0.218 | |
| Humerus n = 79 | 0.977 | 0.035 | 0.100 | 0.020 | 0.096 | 0.061 | | Acromio-radiale n = 80 | 0.892 | 0.178 | 0.115 | 0.050 | 0.233 n=79 | 0.149 | |
| Radius n = 80 | 0.993 | 0.018 | 0.068 | 0.009 | 0.035 | 0.030 | | | | | | | | | |
| Ulna n = 80 | 0.992 | 0.009 | 0.073 | 0.013 | 0.044 | 0.030 | | Radio-stylion n = 80 | 0.795 | 0.286 | 0.076 | 0.045 | 0.205 n=75 | 0.138 | |
| Tibia n = 80 | 0.995 | 0.006 | 0.114 | 0.019 | 0.055 | 0.046 | | | | | | | | | |
| Fibula n = 80 | 0.994 | 0.011 | 0.105 | 0.018 | 0.054 | 0.046 | | Genu-malleolus n = 80 | 0.896 | 0.194 | 0.116 | 0.046 | 0.205 n=78 | 0.130 | |

$n$ = no. of cases used for the calculations.
$r$ = coefficient of correlation.
$\sigma$ = standard deviation.
$b$ = rate of growth in cm. per week
$\sigma_{y.x}$ = deviation of actual measurements about calculated line representing growth.

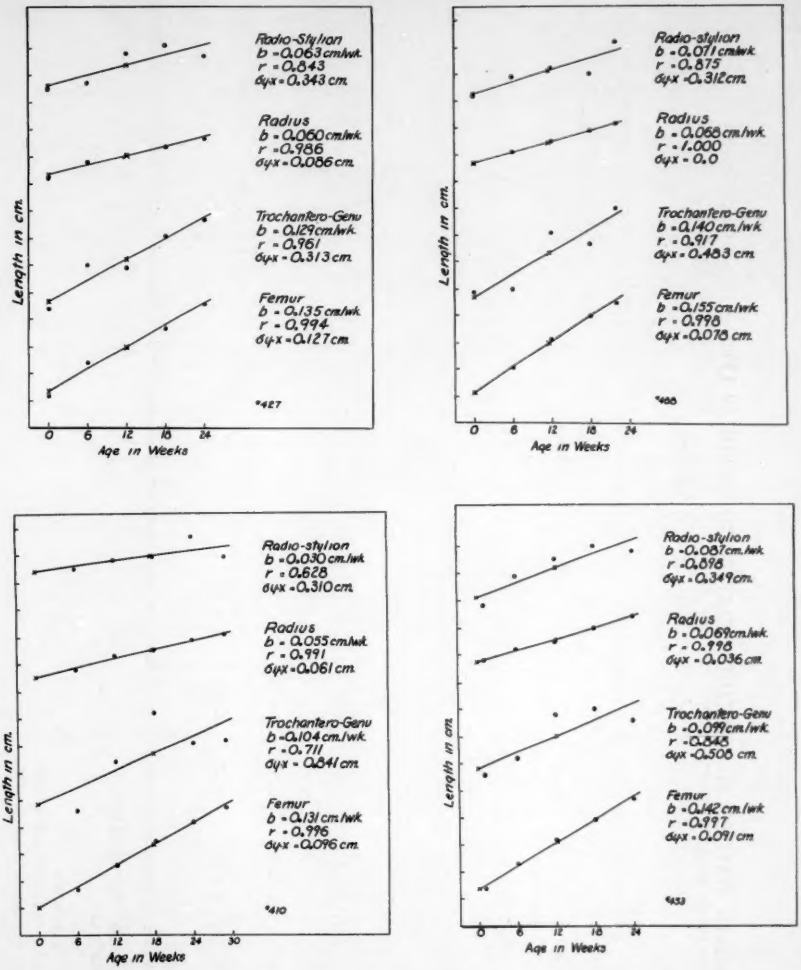


Fig. 4a. The calculated lines ($y = a + bx$) representing rate of growth ($b$) for radius and radio-stylion, and for femur and trochantero-genu are illustrated in 12 cases. The dots represent actual length measurements at each examination. For each line, the crosses (X) represent the calculated birth length ($a$) and the point corresponding to the mean age and mean length of these measurements ($m_x$, $m_y$).

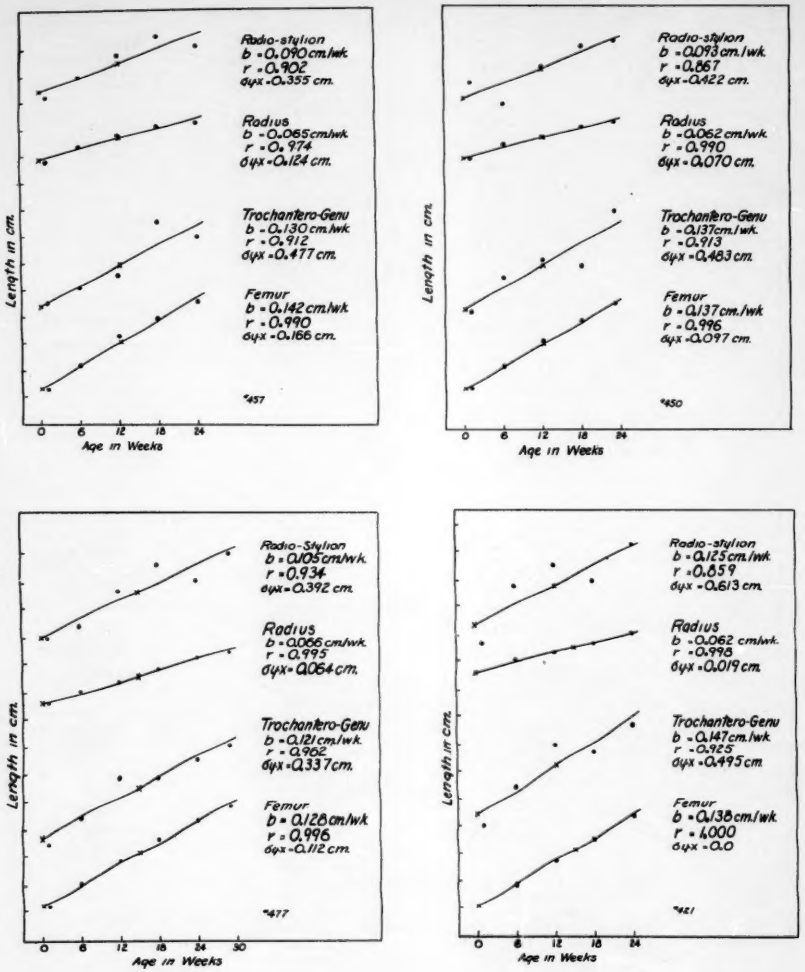


**Fig. 4b.** See legend 4a

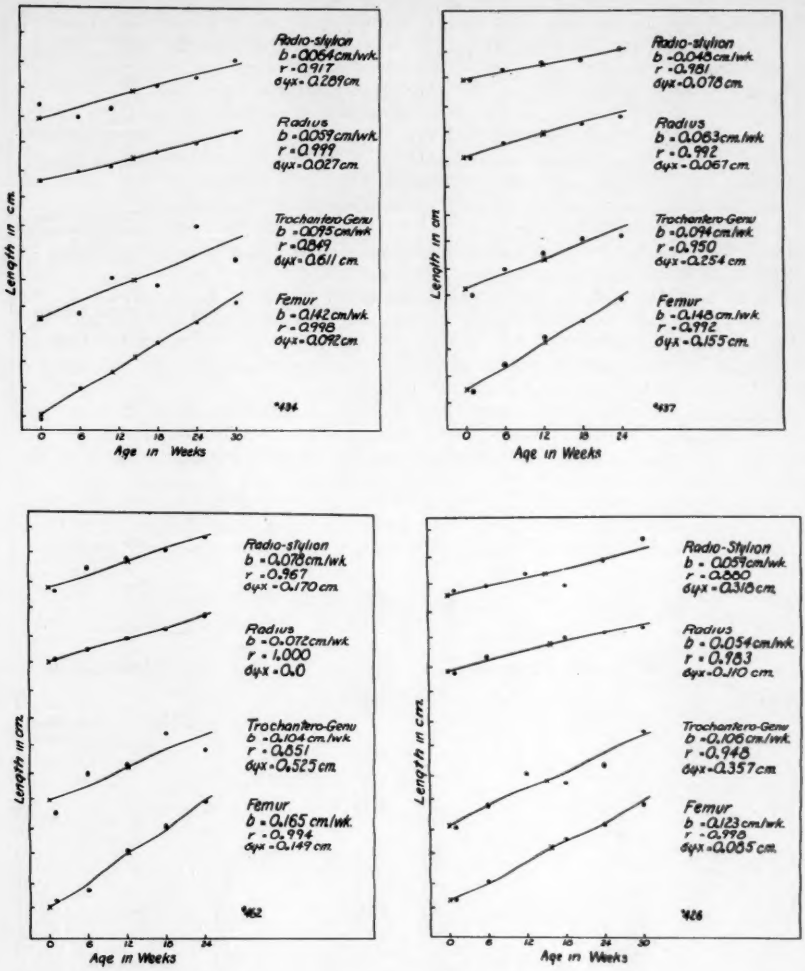


Fig. 4c. See legend 4a

Our next step was to arrange in order of magnitude the individual rates of growth in centimeters per week ($\underline{b}$) as calculated from the X-ray measurements and to group them into lower and upper quartiles with a middle zone combining the two intermediate quartiles. Since the total range of values for $\underline{b}$ was only from 0.103 cm. to 0.199 cm. per week for the femur and from 0.043 cm. to 0.087 cm. per week for the radius, the range of values for $\underline{b}$ in each of the three groups was necessarily small. However, in 77.5 per cent of the cases, the rates of growth for different bones were consistent as to their position within these groups. We have used the term "consistent" when the rates of growth calculated from the X-ray measurements of 4 of the 6 bones fall in the same group.

For the individual rates of growth calculated from the anthropometric measurements, only 50 per cent of the cases showed consistency of position. Here, since only 4 different measurements were used, our standard of "consistency" is agreement in position of 3 of the 4 calculated rates of growth for each child. In each of the 11 instances where the calculated $\underline{b} = 0$, the case was placed arbitrarily in the first quartile. The percentage of cases showing consistency of position of the rates of growth calculated from the anthropometric and X-ray methods of measurement is graphically illustrated in Fig. 5a. Fig. 5a also illustrates the comparison between the percentage of agreement in each of the three groups for both methods of measurement. It will be noted that in each group, the percentage of cases showing consistency with regard to the position of $\underline{b}$ is higher for those rates calculated from the X-ray measurements.

The 34 cases whose rates of growth were calculated from 4 or more examinations each were grouped similarly into lower and upper quartiles and a middle zone. Here the rates calculated from anthropometric measurements showed con-

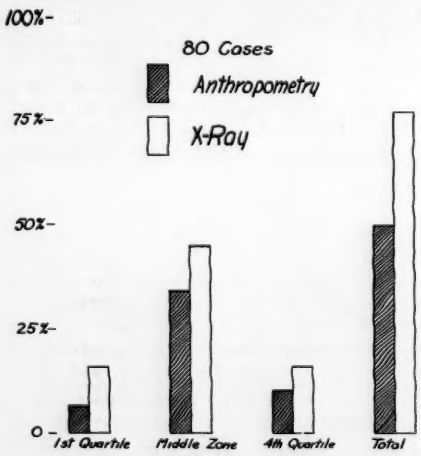


Fig. 5a. The percentage of cases showing consistency of position in quartile groups for rates of growth ($\underline{b}$) calculated from measurements of the roentgenograms and the corresponding anthropometric measurements on 80 infants.

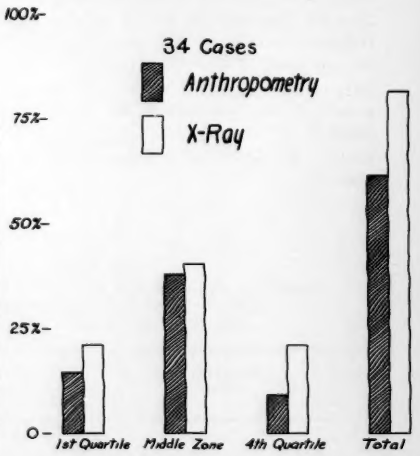


Fig. 5b. The percentage of cases showing consistency of position in quartile groups for rates of growth ($\underline{b}$) calculated from measurements of the roentgenograms and the corresponding anthropometric measurements on 34 infants who had 4 or more examinations each.

sistency of position within the groups for 61.76 per cent of the cases as contrasted with 50 per cent for the series of 80. For the rates of growth calculated from the X-ray measurements, the percentage of cases showing consistency of position within these same groups was only slightly higher for the 34 cases (82.36 per cent) than for the entire series (77.5 per cent). These total percentages for the series of 34, as well as the percentage of agreement for position of b in each of the three groups, are illustrated in Fig. 5b.

It has been stated before that the rates of growth calculated for the individual case from the two methods of measurement were not always comparable. It was not possible to show significant agreement in quartile position between the two calculated rates of growth for the individual cases. In the majority of instances, however, the rates of growth calculated from the X-ray measurements of a given bone and its corresponding anthropometric measurements had the same relative position with regard to the mean rate as calculated by each method. (Table 2.) For example, 63.75 per cent of the cases had rates of growth for radius and radio-stylion which agreed with regard to position either above or below the means. The percentages given in Table 2 are not large enough to be very significant but do suggest a certain agreement in individual rates of growth as calculated by the two methods. Obviously one inaccurate anthropometric measurement will greatly influence the rate of growth calculated from a series of 3 or 4 measurements. Since many factors may influence a given anthropometric measurement, they are much more subject to error than X-ray measurements. Also it is never possible to check an anthropometric measurement at a later date when it is suspected of being inaccurate.

Using the rates of growth in centimeters per week (b) as calculated from the X-ray measurements alone, a search was made for possible factors which might influence the rate of growth of a given bone. Taking the femur as an example, we found no evidence that the length of the bone at birth was a determining factor in the rate of growth process during the first six months of life. Nor did the body weight at birth have any apparent influence on the rate of growth of the bone. There was suggestive evidence that the femur grew more rapidly in those infants whose body length at birth was greater than the mean length for the group, and in those infants whose weight gain per week exceeded the average for the group.

TABLE 2

PERCENTAGE OF CASES SHOWING AGREEMENT OF POSITION ABOVE OR BELOW THE MEAN FOR RATES OF GROWTH (b) CALCULATED FROM MEASUREMENTS OF THE ROENTGENOGRAMS AND THE CORRESPONDING ANTHROPOMETRIC MEASUREMENTS ON 80 INFANTS

| Comparison between | Both b's below Mean b for group | | Both b's above Mean b for group | | Total % of group showing agreement |
|---|---|---|---|---|---|
| | Number of cases | % of group | Number of cases | % of group | |
| Radius : radio-stylion | 27 | 33.75% | 24 | 30.00% | 63.75% |
| Ulna : radio-stylion | 24 | 30.00% | 26 | 32.50% | 62.50% |
| Femur : trochantero-genu | 25 | 31.25% | 22 | 27.50% | 58.75% |
| Tibia : genu-malleolus | 26 | 32.50% | 21 | 26.25% | 58.75% |
| Fibula : genu-malleolus | 25 | 31.25% | 21 | 26.25% | 57.50% |
| Humerus : acromio-radiale | 23 | 29.11% | 21 | 26.58% | 55.69% |

RELATIONS BETWEEN THE LENGTHS OF DIFFERENT BONES AS MEASURED FROM THE ROENTGENOGRAMS

That there is a high degree of correlation between the length of one bone and the length of another as measured from the roentgenograms at any period during the first six months of life is shown in Table 3. These coefficients of correlation ranged from 0.995 for tibia-fibula to 0.932 for humerus-ulna. Ratios between the lengths of the various bones measured are shown in Table 4. There was some evidence that the ratios increased slightly with increasing age even during the first six months of life. This increase was so small that it was not significant in determining the percentage of the group that fell within plus or minus one or two standard deviations from the mean. It should be understood that these ratios will not necessarily hold for other age periods, but they should give a fair standard of the proportionate lengths of different bones during the first six months of life.

The measurements from which all the calculations were made are appended as Table 5.

TABLE 3

COEFFICIENTS OF CORRELATION BETWEEN LENGTHS OF BONES AS MEASURED FROM THE ROENTGENOGRAMS OF 80 INFANTS

| Bones compared | $n$ | $r$ | $\sigma_r$ |
|---|---|---|---|
| Femur and Fibula | 292 | 0.958 | 0.005 |
| Femur and Tibia | 292 | 0.980 | 0.002 |
| Femur and Humerus | 291 | 0.965 | 0.004 |
| Humerus and Radius | 291 | 0.939 | 0.007 |
| Humerus and Ulna | 291 | 0.932 | 0.008 |
| Radius and Fibula | 292 | 0.970 | 0.003 |
| Ulna and Tibia | 292 | 0.970 | 0.003 |
| Radius and Ulna | 292 | 0.981 | 0.002 |
| Tibia and Fibula | 292 | 0.995 | 0.001 |

$n$ = no. of pairs of measurements.
$r$ = coefficient of correlation.
$\sigma_r$ = standard deviation of the coefficient of correlation.

TABLE 4

MEAN VALUES OF THE RATIOS BETWEEN LENGTHS OF DIFFERENT BONES AS MEASURED FROM THE ROENTGENOGRAMS OF 80 INFANTS

| Bones compared | No. of pairs of measurements | Mean ratio | $\sigma$ | % ratios within $\pm 1\sigma$ from the mean | % ratios within $\pm 2\sigma$ from the mean |
|---|---|---|---|---|---|
| $\frac{\text{Humerus}}{\text{Radius}}$ | 291 | 1.2482 : 1 | 0.0496 | 67.70% | 95.88% |
| $\frac{\text{Humerus}}{\text{Ulna}}$ | 291 | 1.0995 : 1 | 0.0453 | 62.54% | 95.53% |
| $\frac{\text{Femur}}{\text{Humerus}}$ | 291 | 1.2212 : 1 | 0.0472 | 66.67% | 94.16% |
| $\frac{\text{Femur}}{\text{Tibia}}$ | 292 | 1.2136 : 1 | 0.0381 | 68.49% | 95.21% |
| $\frac{\text{Femur}}{\text{Fibula}}$ | 292 | 1.2843 : 1 | 0.0501 | 70.55% | 94.18% |

TABLE 5a

INDIVIDUAL MEASUREMENT OF BONES

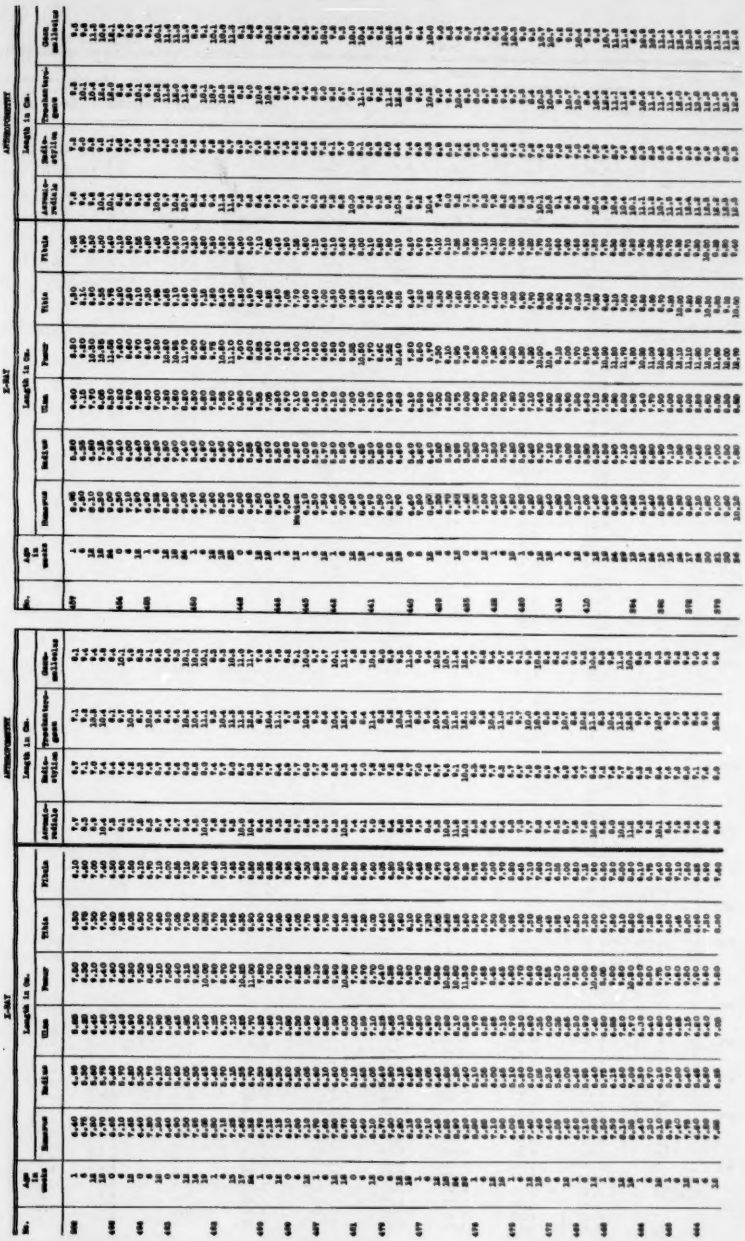

TABLE 5b

INDIVIDUAL MEASUREMENTS ON GIRLS

| No. | Age in weeks | X-RAY: Length in Cm. | | | | | | ANTHROPOMETRY: Length in Cm. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Humerus | Radius | Ulna | Femur | Tibia | Fibula | Acromio-radiale | Radio-stylion | Trochantero-genu | Genu-malleolus |
| 505 | 0 | 6.90 | 5.50 | 6.40 | 8.00 | 6.80 | 6.40 | 8.2 | 7.0 | 8.5 | 8.9 |
| | 6 | 7.60 | 5.85 | 6.70 | 8.80 | 7.55 | 7.10 | 9.0 | 7.2 | 10.0 | 9.9 |
| | 11 | 7.90 | 6.30 | 7.30 | 9.60 | 8.10 | 7.60 | 8.9 | 8.3 | 10.7 | 9.8 |
| | 14 | 8.10 | 6.55 | 7.50 | 10.00 | 8.45 | 7.95 | 10.2 | 8.2 | 10.0 | 10.4 |
| 501 | 1 | 6.50 | 5.20 | 5.90 | 7.50 | 6.45 | 6.10 | 7.0 | 6.4 | 8.0 | 8.0 |
| | 6 | 7.00 | 5.60 | 6.40 | 8.45 | 7.00 | 6.60 | 8.4 | 7 | 9.3 | 8.8 |
| | 12 | 7.70 | 6.00 | 6.90 | 9.30 | 7.70 | 7.20 | 8.8 | 7.5 | 10.3 | 9.6 |
| | 15 | 7.90 | 6.25 | 7.10 | 9.80 | 8.00 | 7.40 | 9.6 | 7.9 | 11.5 | 10.4 |
| 500 | 0 | 6.25 | 5.10 | 5.85 | 7.60 | 6.40 | 6.05 | 6.3 | 7.3 | 9.3 | 8.2 |
| | 6 | 6.90 | 5.50 | 6.35 | 8.50 | 7.10 | 6.70 | 7.6 | 6.8 | 9.7 | 8.7 |
| | 12 | 7.20 | 5.95 | 6.80 | 9.50 | 7.80 | 7.40 | 8.7 | 7.7 | 10.4 | 9.5 |
| 497 | 0 | 6.45 | 5.35 | 6.20 | 7.90 | 6.30 | 5.95 | 7.8 | 6.5 | 8.9 | 8.9 |
| | 6 | 7.10 | 5.75 | 6.55 | 8.80 | 7.20 | 6.90 | 8.4 | 7.4 | 9.9 | 9.5 |
| | 12 | 7.55 | 6.15 | 6.90 | 9.65 | 7.75 | 7.40 | 9.4 | 8.0 | 10.0 | 9.8 |
| 495 | 0 | 6.60 | 5.55 | 6.20 | 7.90 | 6.70 | 6.30 | 7.3 | 6.2 | 8.9 | 8.5 |
| | 6 | 7.30 | 6.00 | 6.75 | 8.95 | 7.45 | 7.00 | 8.3 | 7.7 | 9.7 | 9.2 |
| | 12 | 7.80 | 6.40 | 7.20 | 9.90 | 8.10 | 7.60 | 8.8 | 7.3 | 11.0 | 10.5 |
| 494 | 1 | 6.50 | 5.25 | 5.90 | 7.70 | 6.60 | 6.30 | 7.8 | 6.7 | 9.0 | 8.0 |
| | 6 | 7.20 | 5.65 | 6.40 | 8.45 | 7.15 | 6.80 | 8.4 | 7.3 | 9.7 | 9.4 |
| | 12 | 7.60 | 5.95 | 6.65 | 9.40 | 7.60 | 7.30 | 9.8 | 6.9 | 10.8 | 10.5 |
| 491 | 1 | 6.70 | 5.40 | 6.30 | 8.10 | 6.70 | 6.25 | 8.4 | 7.6 | 9.0 | 8.8 |
| | 6 | 7.00 | 5.80 | 6.70 | 8.90 | 7.40 | 7.00 | 8.8 | 7.4 | 10.4 | 9.7 |
| | 12 | 7.80 | 6.20 | 7.05 | 9.80 | 8.15 | 7.65 | 9.5 | 8.1 | 11.1 | 9.9 |
| | 16 | 8.30 | 6.40 | 7.30 | 10.40 | 8.50 | 7.95 | 9.6 | 7.5 | 10.3 | 10.2 |
| 488 | 0 | 6.90 | 5.65 | 6.40 | 8.15 | 7.00 | 6.60 | 8.4 | 7.2 | 9.9 | 9.2 |
| | 6 | 7.70 | 6.10 | 6.90 | 9.05 | 7.40 | 6.90 | 8.5 | 7.9 | 10.0 | 9.6 |
| | 12 | 8.40 | 6.50 | 7.35 | 10.15 | 8.30 | 7.80 | 9.5 | 8.2 | 12.1 | 10.6 |
| | 18 | 8.90 | 6.90 | 7.80 | 11.00 | 8.90 | 8.30 | 10.8 | 8.0 | 11.7 | 11.0 |
| | 22 | 9.20 | 7.15 | 8.00 | 11.50 | 9.30 | 8.70 | 10.3 | 9.2 | 13.0 | 11.5 |
| 485 | 0 | 6.40 | 5.45 | 6.20 | 7.90 | 6.60 | 6.30 | 8.1 | 7.6 | 9.6 | 8.8 |
| | 6 | 7.40 | 5.85 | 6.75 | 8.80 | 7.35 | 6.95 | 8.9 | 7.9 | 9.5 | 9.4 |
| | 12 | 7.95 | 6.20 | 7.10 | 9.65 | 8.00 | 7.45 | 9.0 | 7.3 | 10.9 | 10.8 |
| 484 | 1 | 7.05 | 5.70 | 6.50 | 8.40 | 6.90 | 6.60 | 8.9 | 8.1 | 10.1 | 9.1 |
| | 6 | 7.55 | 6.00 | 6.75 | 9.25 | 7.60 | 7.15 | 9.3 | 8.4 | 9.9 | 10.1 |
| | 12 | 8.20 | 6.30 | 7.15 | 10.00 | 8.20 | 7.70 | 9.7 | 8.7 | 11.3 | 10.6 |
| 483 | 0 | 6.35 | 4.95 | 5.75 | 7.30 | 6.15 | 5.80 | 7.7 | 6.4 | 7.2 | 8.1 |
| | 6 | 7.20 | 5.50 | 6.25 | 8.25 | 6.90 | 6.50 | 8.1 | 6.9 | 8.2 | 8.7 |
| | 12 | 7.70 | 5.90 | 6.70 | 9.25 | 7.80 | 7.10 | 9.9 | 7.5 | 10.0 | 10.1 |
| 480 | 1 | 6.60 | 5.20 | 5.50 | 7.70 | 6.35 | 6.05 | 8.0 | 6.3 | 9.1 | 8.4 |
| | 6 | 7.10 | 5.70 | 6.35 | 8.50 | 7.10 | 6.70 | 8.0 | 7.2 | 9.1 | 8.8 |
| | 12 | 7.40 | 5.95 | 6.70 | 9.40 | 7.70 | 7.25 | 8.9 | 7.7 | 11.3 | 9.6 |
| 478 | 0 | 6.70 | 5.35 | 6.05 | 7.60 | 6.30 | 6.00 | 7.6 | 7.3 | 8.2 | 8.4 |
| | 6 | 7.50 | 5.90 | 6.50 | 8.75 | 7.10 | 6.70 | 8.1 | 7.5 | 9.8 | 9.5 |
| | 12 | 8.10 | 6.15 | 6.90 | 9.60 | 7.90 | 7.40 | 9.7 | 7.6 | 10.5 | 10.0 |
| | 18 | 8.45 | 6.55 | 7.30 | 10.30 | 8.50 | 7.85 | 10.3 | 9.2 | 12.0 | 11.0 |
| | 24 | 8.90 | 6.85 | 7.60 | 11.00 | 9.00 | 8.35 | 10.8 | 8.9 | 12.3 | 11.2 |
| 474 | 0 | 6.90 | 5.50 | 6.35 | 8.10 | 6.80 | 6.40 | 8.0 | 8.2 | 9.2 | 9.1 |
| | 6 | 7.60 | 6.05 | 6.90 | 9.15 | 7.60 | 7.00 | 8.7 | 8.0 | 10.0 | 9.6 |
| | 12 | 8.20 | 6.40 | 7.20 | 9.95 | 8.10 | 7.50 | 9.1 | 8.2 | 10.7 | 9.6 |
| 473 | 1 | 6.80 | 5.65 | 6.50 | 8.40 | 6.40 | 6.20 | 7.8 | 6.6 | 9.5 | 8.5 |
| | 6 | 6.95 | 6.00 | 6.85 | 9.20 | 7.30 | 7.05 | 9.0 | 7.8 | 9.3 | 9.2 |
| | 12 | 8.30 | 6.4 | 7.25 | 10.30 | 8.25 | 7.90 | 9.8 | 8.0 | 10.2 | 10.2 |
| | 18 | 8.90 | 6.70 | 7.60 | 11.05 | 8.80 | 8.50 | 10.7 | 9.0 | 11.7 | 11.8 |
| | 24 | 9.10 | 7.10 | 8.10 | 11.80 | 9.40 | 9.00 | 11.5 | 8.7 | 13.8 | 11.7 |
| 471 | 0 | 6.70 | 5.20 | 6.10 | 7.80 | 6.35 | 6.00 | 6.9 | 7.2 | 8.7 | 8.6 |
| | 6 | 7.00 | 5.70 | 6.40 | 8.80 | 7.05 | 6.60 | 8.8 | 7.8 | 9.6 | 8.5 |
| | 12 | 8.00 | 6.00 | 6.80 | 9.80 | 7.80 | 7.20 | 8.8 | 7.7 | 10.0 | 9.7 |
| 467 | 1 | 6.00 | 5.20 | 5.90 | 7.90 | 6.30 | 6.00 | 8.2 | 6.9 | 9.1 | 8.8 |
| | 6 | 7.00 | 5.55 | 6.20 | 8.70 | 7.00 | 6.65 | 8.0 | 7.2 | 10.0 | 9.2 |
| | 12 | 7.60 | 5.90 | 6.70 | 9.70 | 7.60 | 7.20 | 9.1 | 8.0 | 9.5 | 9.8 |
| 463 | 0 | 6.30 | 4.90 | 5.60 | 7.70 | 6.40 | 5.90 | 7.4 | 5.8 | 7.9 | 8.7 |
| | 6 | 7.05 | 5.25 | 6.15 | 8.55 | 7.20 | 6.70 | 8.2 | 7.4 | 10.4 | 9.6 |
| | 12 | 7.40 | 5.60 | 6.60 | 9.40 | 7.75 | 7.30 | 9.3 | 7.8 | 9.8 | 10.4 |
| 462 | 1 | 5.80 | 5.10 | 5.75 | 7.30 | 5.90 | 5.65 | 7.6 | 6.6 | 8.5 | 8.2 |
| | 6 | 6.70 | 5.45 | 6.15 | 7.75 | 6.30 | 6.10 | 7.8 | 7.5 | 10.0 | 8.4 |
| | 12 | 7.60 | 5.90 | 6.70 | 9.10 | 7.20 | 6.85 | 9.2 | 7.8 | 10.3 | 9.5 |
| | 18 | 8.40 | 6.30 | 7.25 | 10.10 | 7.90 | 7.65 | 10.1 | 8.1 | 11.5 | 10.6 |
| | 24 | 8.55 | 6.75 | 7.70 | 10.90 | 8.60 | 8.20 | 10.0 | 8.6 | 10.6 | 11.0 |
| 461 | 1 | 6.20 | 5.60 | 6.20 | 7.80 | 6.50 | 6.10 | 7.4 | 7.2 | 8.6 | 8.7 |
| | 6 | 7.00 | 5.90 | 6.70 | 8.80 | 7.40 | 7.00 | 8.7 | 7.5 | 10.5 | 9.8 |
| | 12 | 7.85 | 6.30 | 7.05 | 9.80 | 8.10 | 7.65 | 9.5 | 8.0 | 11.2 | 10.4 |
| 460 | 0 | 6.00 | 4.90 | 5.70 | 7.30 | 5.90 | 5.60 | 7.6 | 6.8 | 8.3 | 8.0 |
| | 6 | 6.90 | 5.40 | 6.10 | 8.20 | 6.90 | 6.55 | 7.7 | 7.0 | 9.0 | 8.5 |
| | 12 | 7.60 | 5.75 | 6.60 | 9.20 | 7.40 | 7.00 | 9.1 | 7.5 | 9.8 | 9.6 |
| 459 | 1 | 5.90 | 4.90 | 5.80 | 7.20 | 5.50 | 5.15 | 7.2 | 5.8 | 8.5 | 7.8 |
| | 6 | 6.30 | 5.40 | 6.30 | 8.30 | 6.40 | 5.90 | 7.6 | 6.9 | 10.0 | 8.6 |
| | 12 | 7.30 | 5.75 | 6.70 | 9.20 | 7.30 | 6.80 | 9.2 | 7.4 | 10.5 | 10.0 |
| 458 | 0 | 6.15 | 5.10 | 5.90 | 7.50 | 6.20 | 5.90 | 8.1 | 7.2 | 8.5 | 8.3 |
| | 6 | 6.90 | 5.45 | 6.20 | 8.30 | 6.80 | 6.40 | 8.4 | 6.6 | 8.8 | 8.4 |
| | 12 | 7.35 | 5.80 | 6.40 | 8.80 | 7.10 | 6.70 | 8.3 | 7.7 | 9.8 | 9.2 |
| | 18 | 7.65 | 5.90 | 6.55 | 9.40 | 7.50 | 7.00 | 9.0 | 7.1 | 10.4 | 9.9 |
| 452 | 1 | 6.90 | 5.30 | 6.20 | 8.00 | 6.00 | 5.80 | 7.8 | 7.3 | 9.1 | 8.2 |
| | 6 | 7.20 | 5.80 | 6.60 | 8.80 | 7.05 | 6.85 | 9.0 | 6.8 | 9.3 | 9.0 |
| | 12 | 7.90 | 5.95 | 6.95 | 9.80 | 7.70 | 7.40 | 9.4 | 7.9 | 10.6 | 9.7 |
| 451 | 1 | 6.80 | 4.90 | 5.70 | 7.70 | 6.30 | 6.10 | 7.6 | 6.4 | 8.2 | 8.2 |
| | 7 | 7.40 | 5.60 | 6.40 | 8.80 | 7.10 | 6.80 | 9.2 | 7.0 | 9.9 | 9.3 |
| | 12 | 7.90 | 5.85 | 6.70 | 9.55 | 7.60 | 7.35 | 9.5 | 7.4 | 7.7 | 10.2 |

TABLE 5b (Continued)

| No. | Age in weeks | X-RAY: Length in Cm. | | | | | | ANTHROPOMETRY: Length in Cm. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Humerus | Radius | Ulna | Femur | Tibia | Fibula | Acromio-radiale | Radio-stylion | Trochantero-geon | Genu-malleolus |
| 447 | 0 | 5.50 | 4.50 | 5.20 | 6.60 | 5.70 | 5.40 | 7.0 | 6.4 | 8.1 | 7.4 |
| | 6 | 6.25 | 5.00 | 5.60 | 7.50 | 6.40 | 6.05 | 8.3 | 6.5 | 9.4 | 8.3 |
| | 12 | 6.90 | 5.30 | 6.00 | 8.40 | 7.00 | 6.60 | 8.0 | 7.3 | 9.3 | 9.0 |
| | 18 | 7.50 | 5.75 | 6.40 | 9.10 | 7.40 | 7.00 | 8.6 | 7.9 | 10.8 | 9.9 |
| 444 | 1 | 6.50 | 5.10 | 5.90 | 7.40 | 5.90 | 5.70 | 8.2 | 7.1 | 8.1 | 8.0 |
| | 6 | 7.10 | 5.50 | 6.25 | 8.00 | 6.60 | 6.30 | 8.3 | 7.3 | 8.9 | 8.3 |
| | 12 | 7.40 | 5.90 | 6.70 | 8.80 | 7.40 | 7.00 | 8.7 | 7.1 | 9.5 | 9.3 |
| | 18 | 8.10 | 6.20 | 7.00 | 9.70 | 8.00 | 7.65 | 9.2 | 8.2 | 11.3 | 10.6 |
| 438 | 2 | 6.80 | 5.50 | 6.30 | 8.10 | 6.90 | 6.50 | 7.8 | 6.9 | 9.8 | 8.7 |
| | 6 | 7.10 | 5.70 | 6.40 | 8.80 | 7.10 | 6.80 | 8.2 | 7.0 | 9.1 | 9.9 |
| | 12 | 7.90 | 6.20 | 7.00 | 9.80 | 8.00 | 7.55 | 9.2 | 7.2 | 10.2 | 10.1 |
| 437 | 1 | 6.40 | 5.10 | 5.80 | 7.40 | 6.40 | 5.90 | 7.4 | 6.9 | 9.0 | 9.1 |
| | 6 | 7.00 | 5.60 | 6.40 | 8.50 | 7.00 | 6.60 | 8.4 | 7.3 | 10.0 | 8.9 |
| | 12 | 7.70 | 5.95 | 6.80 | 9.45 | 7.80 | 7.30 | 8.8 | 7.6 | 10.6 | 9.3 |
| | 18 | 8.10 | 6.30 | 7.20 | 10.10 | 8.25 | 7.80 | 8.8 | 7.7 | 11.1 | 10.1 |
| | 24 | 8.60 | 6.60 | 7.55 | 10.90 | 8.80 | 8.30 | 10.0 | 8.1 | 11.2 | 10.4 |
| 436 | 0 | 6.50 | 5.30 | 5.90 | 7.50 | 6.00 | 5.60 | 8.0 | 6.3 | 9.2 | 8.6 |
| | 6 | 7.10 | 5.80 | 6.50 | 8.80 | 7.10 | 6.60 | 8.8 | 7.6 | 10.0 | 9.3 |
| | 26 | 8.95 | 7.00 | 7.70 | 11.40 | 9.10 | 8.70 | 10.5 | 8.8 | 12.0 | 11.4 |
| 434 | 0 | 6.70 | 5.60 | 6.20 | 7.90 | 6.30 | 6.10 | 8.4 | 7.4 | 9.6 | 9.0 |
| | 6 | 7.30 | 6.00 | 6.80 | 9.00 | 7.10 | 6.70 | 7.8 | 7.0 | 9.8 | 10.5 |
| 434 | 11 | 7.70 | 6.20 | 7.00 | 9.70 | 7.60 | 7.30 | 9.4 | 7.3 | 11.1 | 9.6 |
| | 18 | 8.45 | 6.85 | 7.40 | 10.70 | 8.50 | 7.90 | 10.5 | 8.1 | 10.8 | 10.3 |
| | 24 | 9.05 | 7.00 | 7.80 | 11.50 | 9.10 | 8.50 | 11.0 | 8.4 | 13.0 | 11.3 |
| | 30 | 9.60 | 7.40 | 8.25 | 12.20 | 9.70 | 9.10 | 11.3 | 9.1 | 11.8 | 11.5 |
| 427 | 0 | 6.60 | 5.20 | 6.00 | 8.20 | 6.50 | 6.10 | 7.7 | 6.5 | 8.4 | 8.8 |
| | 6 | 6.90 | 5.80 | 6.60 | 9.40 | 7.00 | 6.40 | 8.2 | 6.7 | 10.0 | 8.6 |
| | 12 | 8.00 | 6.10 | 7.00 | 10.00 | 7.70 | 7.00 | 9.2 | 7.8 | 9.9 | 9.5 |
| | 18 | 8.30 | 6.40 | 7.20 | 10.70 | 8.30 | 7.60 | 10.2 | 8.1 | 11.1 | 9.7 |
| | 24 | 8.65 | 6.70 | 7.50 | 11.80 | 8.90 | 8.10 | 10.5 | 7.7 | 11.7 | 10.1 |
| 426 | 1 | 6.00 | 4.80 | 5.50 | 7.30 | 5.90 | 5.40 | 7.7 | 6.7 | 8.1 | 8.0 |
| | 6 | 6.90 | 5.30 | 6.00 | 8.10 | 6.60 | 5.90 | 7.5 | 6.8 | 8.8 | 8.2 |
| | 12 | Film too poor to measure | | | | | | 9.0 | 7.4 | 10.1 | 9.6 |
| | 18 | 7.80 | 6.00 | 6.70 | 9.60 | 7.60 | 6.90 | 9.1 | 6.9 | 9.7 | 9.1 |
| | 24 | 8.30 | 6.20 | 6.95 | 10.25 | 8.15 | 7.40 | 10.3 | 7.9 | 10.4 | 10.2 |
| | 30 | 8.80 | 6.40 | 7.30 | 10.90 | 8.60 | 7.80 | 10.6 | 8.6 | 11.8 | 10.2 |
| 425 | 1 | 6.70 | 5.40 | 6.10 | 8.20 | 6.90 | 6.50 | 7.5 | 6.4 | 9.1 | 9.9 |
| | 6 | 7.50 | 5.80 | 6.50 | 9.00 | 7.50 | 7.10 | 8.4 | 6.9 | 9.7 | 9.2 |
| | 12 | 7.90 | 6.20 | 7.00 | 10.00 | 8.00 | 7.60 | 9.8 | 7.6 | 11.5 | 10.0 |
| 423 | 0 | 6.30 | 5.30 | 6.10 | 7.80 | 6.70 | 6.10 | 8.0 | 6.4 | 8.9 | 8.3 |
| | 6 | 6.90 | 5.70 | 6.60 | 8.80 | 7.30 | 6.80 | 8.8 | 6.9 | 9.7 | 9.3 |
| | 15 | 7.80 | 6.30 | 7.10 | 9.70 | 8.00 | 7.50 | 9.1 | 7.2 | 9.7 | 10.5 |
| 421 | 1 | Film too poor to measure | | | | | | 9.5 | 5.7 | 8.0 | 9.8 |
| | 6 | 7.50 | 6.00 | 6.80 | 8.90 | 7.40 | 6.90 | 9.4 | 7.8 | 9.5 | 9.1 |
| | 12 | 8.30 | 6.30 | 7.00 | 9.70 | 7.80 | 7.40 | 8.8 | 8.5 | 11.0 | 9.9 |
| | 18 | 8.80 | 6.70 | 7.40 | 10.60 | 8.30 | 7.80 | 10.1 | 8.0 | 10.7 | 10.6 |
| | 24 | 9.15 | 7.10 | 7.80 | 11.35 | 8.80 | 8.35 | 10.7 | 9.3 | 11.7 | 10.8 |
| 418 | 1 | 6.70 | 5.40 | 6.10 | 7.80 | 6.60 | 6.20 | 9.4 | 6.5 | 8.5 | 8.8 |
| | 6 | 7.40 | 5.70 | 6.50 | 8.70 | 7.30 | 6.80 | 8.8 | 7.2 | 9.9 | 8.7 |
| | 12 | 7.50 | 6.10 | 6.80 | 9.60 | 7.90 | 7.30 | 8.9 | 7.5 | 10.0 | 9.5 |
| | 18 | 8.40 | 6.50 | 7.20 | 10.30 | 8.40 | 7.70 | 10.1 | 7.8 | 11.0 | 9.7 |
| | 24 | 9.00 | 6.80 | 7.50 | 11.00 | 8.80 | 8.10 | 9.8 | 7.9 | 11.0 | 10.0 |
| 412 | 1 | 6.40 | 5.00 | 5.80 | 7.50 | 5.70 | 5.50 | 8.7 | 6.3 | 8.8 | 9.6 |
| | 6 | 7.10 | 5.40 | 6.30 | 8.30 | 6.60 | 6.40 | 9.7 | 6.4 | 10.6 | 9.1 |
| | 12 | 7.70 | 5.70 | 6.80 | 9.20 | 7.40 | 7.00 | 8.6 | 7.1 | 9.9 | 8.9 |
| | 18 | 8.00 | 6.10 | 7.10 | 10.00 | 8.00 | 7.60 | 9.6 | 7.5 | 11.5 | 10.2 |
| 407 | 6 | 7.10 | 5.50 | 6.30 | 8.70 | 6.90 | 6.30 | 7.9 | 7.0 | 10.0 | 9.3 |
| | 12 | 7.70 | 5.90 | 6.50 | 9.40 | 7.50 | 6.90 | 8.5 | 7.9 | 9.2 | 10.1 |
| | 18 | 8.00 | 6.10 | 6.80 | 10.10 | 8.00 | 7.40 | 9.4 | 7.3 | 11.5 | 10.4 |
| 398 | 8 | 7.50 | 6.00 | 6.70 | 9.00 | 7.50 | 7.00 | 10.0 | 7.2 | 10.1 | 10.2 |
| | 12 | 8.10 | 6.20 | 7.00 | 9.70 | 7.90 | 7.20 | 11.6 | 7.8 | 10.1 | 9.8 |
| | 18 | 8.30 | 6.60 | 7.40 | 10.50 | 8.80 | 8.00 | 9.7 | 7.7 | 10.2 | 9.8 |
| 391 | 13 | 6.90 | 5.40 | 6.20 | 8.50 | 6.80 | 6.30 | 8.4 | 6.6 | 8.6 | 9.3 |
| | 18 | 7.80 | 5.80 | 6.50 | 9.30 | 7.50 | 7.00 | 9.3 | 7.1 | 9.2 | 9.5 |
| | 24 | 7.50 | 6.10 | 6.90 | 10.00 | 8.00 | 7.50 | 10.1 | 7.7 | 10.5 | 10.3 |

## SUMMARY

Growth of the long bones in the first six months of life, as shown by measurements from serial roentgenograms and by the anthropometric measurements which correspond to the bone lengths, was studied for a group of 80 infants.

Plotting the measurements from the roentgenograms of each child against his age in weeks showed essentially straight-line growth for all bones measured. Growth in length of femur and radius are illustrated. The coefficients of correlation for the individual bone lengths of each child against age were high with mean values ranging from 0.977 to 0.997.

The anthropometric measurements suggested straight-line growth for the individual child but with considerable fluctuation of the actual points about this line. The coefficients of correlation for the anthropometric measurements of each child against age were not uniformly good, the mean values ranging from 0.795 to 0.896.

The individual rates of growth as calculated by the method of least squares were less variable for the measurements from the roentgenograms than for the corresponding anthropometric measurements. However, mean rates of growth for the group of infants as calculated from the two sets of measurements were comparable. These mean values are given in Table 1.

The observed measurements from the roentgenograms of each child showed only very slight deviation from the calculated line representing growth. The observed anthropometric measurements for most of the children showed a much greater scatter about the calculated line.

There is considerable evidence that the rate of growth of any one bone bears a consistent relationship to that of all the bones studied, e.g., a child with a femur which grows rapidly as compared with those of the entire series of children usually shows a rapid rate of growth for his other bones.

There is a very high degree of correlation between the lengths of different bones as measured from the roentgenograms.

Ratios between the different bone lengths were calculated for each child. Mean values for each of these ratios are presented in Table 4 as representative standards for the proportionate lengths of different bones during the first six months of life.

## CONCLUSIONS

For the age period under consideration, it may be concluded that measurements from serial roentgenograms will give mean values for rates of growth of the long bones studied which are comparable with the mean values obtained from a series of the corresponding anthropometric measurements. There is apparently so much error inherent in the anthropometric method of measuring that these measurements in any individual case cannot always be subjected to precise statistical analysis. In contrast to this, measurements from the roentgenograms of each child are sufficiently accurate to be suitable for detailed analysis.

For each of the long bones measured, growth in length appears to proceed at a uniform rate during the first six months of life.

# A SURVEY OF THE ADJUSTMENT OF SCHOOL CHILDREN

MERVIN A. DUREA[1]

## INTRODUCTION

Adjustment is a term which has been employed rather loosely by mental hygienists, applied psychologists, social workers, teachers, and a variety of others concerned with the social welfare of the individual. In a narrow sense adjustment has been interpreted in the light of more or less immediate conditions affecting the individual. The adequacy of one's adjustment, determined by behavior with respect to a fixed goal or situation, is estimated as either completely satisfactory or unsatisfactory. In describing individual behavior this position has stressed the dichotomous and somewhat moralistic classification adjusted-unadjusted. In a broader sense adjustment has been held to connote a continuing process in which the whole personality is scrutinized with reference not only to immediate ends but progressive social effectiveness. Hence, Howard and Patry explain that: "True adjustment includes more than orientation in the externals of human contacts" (3, p.19). Adjustment of the individual, therefore, as described or measured at any given time with reference to a specific situation, is at best only a cross-section. A pupil in the school situation is not either adjusted or unadjusted but may at different times display varying degrees of competency in relation to that particular environment.

With the foregoing considerations in mind it is the purpose of the present study to analyze the adjustment of school children. Quantitatively defined behavior, manifested at different periods through the school year, is assumed to be an expression of pupil adjustment.

## EXPERIMENTAL SETTING

The survey was conducted in cooperation with the school system of a small industrial town in southwestern Ohio, population about 10,000. Subjects were 1838 pupils, representing practically the entire school population. Twelve grades and a few ungraded classes were included in the investigation. Because of certain factors connected with district boundaries the school system is so organized that white and negro children attend different schools at both the elementary and secondary levels. The white and negro schools are served by teachers of the respective races. Undoubtedly the fact of homogeneous racial groupings has contributed no inconsiderable amount to the reliability of results.

As a basis for the survey an Adjustment Score Card devised by Yepsen (4, 5, 6, 7) was employed. This technique consists of fourteen major categories, each dealing with some phase of the adjustment of the individual to his environment. Under these categories are seventy items, each descriptive of some form of conduct. Four to seven items describe in detail each category. The rater is requested to indicate the one item in each category which best describes the subject. Weights are awarded to the various items. Ratings may be made by any one who knows the individual. Following is a sample category from the Adjustment Score Card:

ATTITUDE OF OTHERS TOWARD HIM

| | |
|---|---|
| Choose him as a leader | Seek his companionship |
| Accept him as a leader | Ignore and shun him |
| Play with him occasionally, not often | Accept readily as one of group |
| | Butt of crowd, pick on him |

[1] *From Ohio State University.*

The highest possible score obtainable on the Yepsen form is 148, and the lowest 24.

Prior to launching the project the teachers who acted as raters were given a course of instruction by the writer. An attempt was made to make clear the essential meaning of measurement of personality, its relation to individual differences, and specifically a thorough orientation in the scope and implications of the technique used in this study. Fifty-seven teachers participated in the project.

Monthly ratings were made on each child by the teacher in charge of a group, reports being submitted for consecutive months beginning with October and extending through April. In order to minimize the operation of halo effects the teachers were instructed when making ratings not to use the order in which the names of pupils appeared on class rolls. Each subject's name in a given group was entered on a card. When the time approached for a monthly rating the cards were shuffled and names drawn in random order. Thus a different pattern of names for each grade or class appeared in each set of monthly ratings.

STATISTICAL ANALYSIS

As a means of determining the significant facts of the survey three forms of frequency distribution were made of the adjustment scores: (a) by month for the total population of 1838 pupils; (b) by month for each of six schools; and (c) by month for each of twelve grades and a special group constituted of ungraded classes. Medians, first and third quartiles and quartile deviations were computed for each frequency distribution. Tables 1 and 2 display certain pertinent facts, illustrating the distributions in question.

Each vertical column in Table 1 shows the medians, quartiles, and semi-interquartile ranges for the total school population and six schools in terms of months from October to April. A study of the range of medians footing each vertical column (covering the six schools) is instructive. Yepsen (7), from experimental work with the Score Card, concludes that 100 may be considered as the score which would be obtained by the hypothetically well-adjusted child. An inspection of the vertical columns in Table 1 reveals that medians for the six schools center month to month closely around 100. The largest range of medians (97 to 106) occurs in the month of January. For the months of October and February the range of medians is the smallest, being in each case 99 to 103.

Horizontal rows in Table 1 show the medians, $Q_1$'s, $Q_3$'s, and Q's for the total school population and each school covering a period of seven months. Considering the range of medians for each school, it will be noted that these too tend to cluster around 100. Three schools, II, IV, and VI, have ranges of 5 points. School III has a range of 2 points. Schools V and VI, attended by negro children, are not differentiated markedly from schools attended by white children. In general the departures of the medians of each school from 100 is negligible.

An analysis, similar to that for the schools and total school population, has been made for the twelve grades and special group. In each vertical column in Table 2 is shown the medians, quartiles, and semi-interquartile ranges of the twelve grades and special group by months. At the foot of each vertical column is the range of medians for a particular month. On the average the ranges of medians for grades are considerably greater than for schools. The largest ranges are found in December, January, and March, each being 22 points. The smallest range is for October, this being 12 points. Each horizontal row in Table 2 shows the medians, $Q_1$'s, $Q_3$'s, and Q's, for each grade month to month. The twelfth grade, with a spread of 11 points, has the greatest range of medians. Three grades, fourth, ninth, and the special group have ranges of 3 points, the smallest. On the whole the range of medians within each grade is much less restricted than

TABLE 1

MONTHLY MEDIANS, $Q_1$'s, $Q_3$'s, AND Q's FOR SCORES ON YEPSEN ADJUSTMENT SCORE CARD: TOTAL SYSTEM AND SCHOOLS*

| Unit | N | Measures | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | Range of Medians |
|---|---|---|---|---|---|---|---|---|---|---|
| Total System | 1838 | Mdn. | 101 | 100 | 103 | 103 | 102 | 101 | 100 | 100-103 |
| | | $Q_1$ | 85 | 85 | 87 | 88 | 87 | 85 | 85 | |
| | | $Q_3$ | 114 | 114 | 114 | 115 | 115 | 113 | 112 | |
| | | Q | 14.5 | 14.5 | 13.5 | 13.5 | 14.0 | 14.0 | 13.5 | |
| Schools | | Mdn. | 102 | 101 | 104 | 103 | 103 | 103 | 100 | 100-104 |
| | | $Q_1$ | 90 | 89 | 92 | 91 | 91 | 91 | 88 | |
| I | 621 | $Q_3$ | 114 | 114 | 114 | 114 | 115 | 114 | 115 | |
| | | Q | 12.0 | 12.5 | 11.0 | 11.5 | 12.0 | 11.5 | 13.5 | |
| | | Mdn. | 100 | 99 | 99 | 101 | 103 | 98 | 98 | 98-103 |
| | | $Q_1$ | 82 | 79 | 83 | 84 | 85 | 80 | 81 | |
| II | 438 | $Q_3$ | 112 | 111 | 112 | 113 | 112 | 109 | 109 | |
| | | Q | 15.0 | 16.0 | 14.5 | 14.5 | 13.5 | 14.5 | 14.0 | |
| | | Mdn. | 103 | 102 | 101 | 103 | 101 | 102 | 102 | 101-103 |
| | | $Q_1$ | 78 | 80 | 79 | 87 | 84 | 80 | 87 | |
| III | 256 | $Q_3$ | 117 | 117 | 115 | 118 | 116 | 114 | 115 | |
| | | Q | 19.5 | 18.5 | 18.0 | 15.5 | 16.0 | 17.0 | 14.0 | |
| | | Mdn. | 101 | 96 | 98 | 96 | 99 | 98 | 98 | 96-101 |
| | | $Q_1$ | 85 | 75 | 79 | 74 | 83 | 82 | 82 | |
| IV | 63 | $Q_3$ | 109 | 116 | 113 | 112 | 112 | 108 | 117 | |
| | | Q | 12.0 | 20.5 | 17.0 | 19.0 | 14.5 | 13.0 | 17.5 | |
| | | Mdn. | 99 | 100 | 102 | 102 | 101 | 101 | 101 | 99-102 |
| | | $Q_1$ | 81 | 86 | 87 | 85 | 84 | 80 | 82 | |
| V | 217 | $Q_3$ | 115 | 114 | 114 | 117 | 117 | 116 | 114 | |
| | | Q | 17.0 | 14.0 | 13.5 | 16.0 | 16.5 | 18.0 | 16.0 | |
| | | Mdn. | 101 | 101 | 105 | 106 | 103 | 103 | 103 | 101-106 |
| | | $Q_1$ | 83 | 86 | 86 | 89 | 86 | 86 | 88 | |
| VI | 243 | $Q_3$ | 118 | 118 | 122 | 126 | 123 | 121 | 122 | |
| | | Q | 17.5 | 16.0 | 18.0 | 18.5 | 18.5 | 17.5 | 17.0 | |
| Range of Medians | | | 99-103 | 96-102 | 98-105 | 97-106 | 99-103 | 98-103 | 98-103 | |

*Schools I to IV are attended by white children. Schools V and VI are attended by negro children.

the ranges within each school. In Table 2 the same general characteristic of the medians is noted as occurred in Table 1, namely, a tendency for medians to cluster around 100.

A slightly different form of analysis than previously discussed was employed as a means of further clarifying the tendencies of data in Tables 1 and 2. The hypothetical value 100 was used as a point of reference and deviations of medians from this value irrespective of direction were computed. For both foregoing tables the deviations of each median in the vertical column and similarly for horizontal rows was found. In Table 1 the total school population was excluded. An illustration will clarify the procedure. In the first vertical column in Table 1 under October the following deviations of medians from 100 occur: 2, 0, 3, 1, 1, 1. These deviations added and divided by 6 (the number of schools) give the value 1.3 - the mean of six deviations from 100. Similar computations were made for each vertical column in Table 1, the resulting series of means of the deviations from 100 being: October 1.3; November 1.5; December 2.5; January

TABLE 2

MONTHLY MEDIANS, $Q_1$'s, $Q_3$'s, and Q's FOR SCORES ON YEPSEN ADJUSTMENT SCORE CARD: SCHOOL GRADES

| Unit | N | Measures | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | Range of Medians |
|---|---|---|---|---|---|---|---|---|---|---|
| Grades | | Mdn. | 95 | 97 | 100 | 101 | 101 | 99 | 98 | 95-101 |
| | | $Q_1$ | 77 | 77 | 79 | 78 | 76 | 75 | 80 | |
| 1 | 164 | $Q_3$ | 116 | 118 | 114 | 119 | 117 | 117 | 115 | |
| | | Q | 19.5 | 20.5 | 17.5 | 20.5 | 20.5 | 21.0 | 17.5 | |
| | | Mdn. | 95 | 97 | 91 | 97 | 95 | 92 | 94 | 92-97 |
| | | $Q_1$ | 79 | 79 | 73 | 80 | 76 | 77 | 80 | |
| 2 | 151 | $Q_3$ | 109 | 109 | 108 | 111 | 107 | 108 | 108 | |
| | | Q | 15.0 | 15.0 | 17.5 | 15.5 | 15.5 | 15.5 | 14.0 | |
| | | Mdn. | 102 | 105 | 106 | 105 | 106 | 104 | 106 | 102-106 |
| | | $Q_1$ | 77 | 78 | 78 | 86 | 83 | 78 | 89 | |
| 3 | 123 | $Q_3$ | 117 | 117 | 118 | 117 | 118 | 114 | 116 | |
| | | Q | 20.0 | 19.5 | 20.0 | 15.5 | 17.5 | 18.0 | 13.5 | |
| | | Mdn. | 105 | 106 | 104 | 106 | 104 | 105 | 103 | 103-106 |
| | | $Q_1$ | 85 | 89 | 92 | 92 | 89 | 88 | 91 | |
| 4 | 161 | $Q_3$ | 116 | 118 | 116 | 122 | 120 | 115 | 116 | |
| | | Q | 15.5 | 14.5 | 12.0 | 14.5 | 15.5 | 13.5 | 12.5 | |
| | | Mdn. | 107 | 102 | 100 | 102 | 103 | 98 | 98 | 98-107 |
| | | $Q_1$ | 88 | 85 | 85 | 91 | 93 | 86 | 90 | |
| 5 | 151 | $Q_3$ | 122 | 116 | 110 | 113 | 115 | 112 | 112 | |
| | | Q | 17.0 | 15.5 | 12.5 | 11.0 | 11.0 | 13.0 | 11.0 | |
| | | Mdn. | 103 | 103 | 107 | 109 | 106 | 104 | 103 | 103-109 |
| | | $Q_1$ | 90 | 91 | 92 | 93 | 94 | 97 | 91 | |
| 6 | 168 | $Q_3$ | 113 | 116 | 118 | 122 | 120 | 117 | 121 | |
| | | Q | 11.5 | 12.5 | 13.0 | 14.5 | 13.0 | 10.0 | 15.0 | |
| | | Mdn. | 103 | 102 | 106 | 105 | 105 | 101 | 103 | 101-106 |
| | | $Q_1$ | 86 | 83 | 90 | 85 | 78 | 87 | 83 | |
| 7 | 118 | $Q_3$ | 115 | 118 | 120 | 119 | 121 | 118 | 115 | |
| | | Q | 14.5 | 17.5 | 15.0 | 17.0 | 21.5 | 15.5 | 16.0 | |
| | | Mdn. | 99 | 97 | 102 | 99 | 98 | 93 | 98 | 93-102 |
| | | $Q_1$ | 77 | 78 | 85 | 81 | 78 | 73 | 73 | |
| 8 | 77 | $Q_3$ | 114 | 108 | 111 | 110 | 113 | 111 | 107 | |
| | | Q | 18.5 | 15.0 | 13.0 | 14.5 | 17.5 | 19.0 | 17.0 | |
| | | Mdn. | 101 | 99 | 99 | 101 | 100 | 101 | 98 | 98-101 |
| | | $Q_1$ | 92 | 84 | 87 | 87 | 93 | 87 | 88 | |
| 9 | 165 | $Q_3$ | 111 | 108 | 109 | 112 | 111 | 113 | 109 | |
| | | Q | 9.5 | 12.0 | 11.0 | 12.5 | 9.0 | 13.0 | 10.5 | |
| | | Mdn. | 100 | 99 | 102 | 98 | 97 | 94 | 96 | 94-102 |
| | | $Q_1$ | 86 | 87 | 88 | 87 | 84 | 79 | 85 | |
| 10 | 167 | $Q_3$ | 108 | 108 | 107 | 106 | 105 | 99 | 104 | |
| | | Q | 11.0 | 10.5 | 9.5 | 9.5 | 10.5 | 10.0 | 9.5 | |
| | | Mdn. | 107 | 105 | 107 | 108 | 112 | 106 | 105 | 105-112 |
| | | $Q_1$ | 97 | 92 | 96 | 100 | 104 | 96 | 91 | |
| 11 | 133 | $Q_3$ | 122 | 114 | 118 | 116 | 122 | 116 | 116 | |
| | | Q | 12.5 | 11.0 | 11.0 | 8.0 | 9.0 | 10.0 | 12.5 | |
| | | Mdn. | 106 | 113 | 113 | 117 | 111 | 114 | 107 | 106-117 |
| | | $Q_1$ | 96 | 99 | 100 | 104 | 101 | 105 | 99 | |
| 12 | 75 | $Q_3$ | 116 | 119 | 120 | 127 | 123 | 129 | 125 | |
| | | Q | 10.0 | 10.0 | 10.0 | 11.5 | 11.0 | 12.0 | 13.0 | |
| | | Mdn. | 97 | 94 | 96 | 95 | 96 | 95 | 94 | 94-97 |
| | | $Q_1$ | 78 | 77 | 78 | 78 | 78 | 78 | 80 | |
| Special | 185 | $Q_3$ | 112 | 115 | 113 | 112 | 111 | 109 | 112 | |
| | | Q | 17.0 | 19.0 | 17.5 | 17.0 | 16.5 | 15.5 | 16.0 | |
| Range of Medians | | | 95-107 | 94-113 | 91-113 | 95-117 | 95-112 | 92-114 | 94-107 | |

2.0; February 2.0; March 2.2; April 1.7.

Horizontal rows in Table 1 record the monthly median adjustment scores for the different schools. Employing the deviations from 100 of each median of a series (each series representing a school) and computing the mean of each series of deviations, irrespective of direction of deviation, the following results are obtained: School I, 2.3; II, 1.4; III, 2.0; IV, 2.3; V, 1.1; and VI, 3.1. Schools V and VI, as stated previously are attended by negro children. From these facts it is evident that the difference on the average between the typical adjustment of white and negro pupils is insignificant. Medians of all groups center closely around 100.

Median adjustment scores for the grades (vertical columns of Table 2) and each separate grade (horizontal rows in Table 2) exhibit certain tendencies which should be noted. For each month the mean of the deviations of the medians from 100, plus and minus deviations ignored, are: October 3.7; November 4.1; December 4.8; January 5.0; February 4.8; March 5.4; April 3.9. On the average there is considerably greater divergence from 100 of the medians among the grades than among the schools. For each grade and the special group, calculation of the mean of the deviations from 100 yielded the following series of values: first grade, 3.1; second 5.6; third, 4.9; fourth, 4.7; fifth, 2.6; sixth, 5.0; seventh, 3.6; eighth, 2.6; ninth, 1.0; tenth, 2.6; eleventh, 7.1; twelfth, 11.6; and special 4.7. A rather wide range in these values is noticeable, from 1.0 for the ninth grade to 11.6 for the twelfth.

From the analysis thus far it may be concluded that on the average the central tendencies of the total group, each of six schools, and each of twelve grades and a special group show no markedly significant departures from the typical adjustment score posited by Yepsen. A not unimportant point however, is the consistent direction of deviations of the medians from 100 in the case of several grades. For instance, seven medians for the second grade all deviate in a minus direction, while medians for adjacent grades three and four all deviate in a plus direction. Again, while the direction of deviations for grade ten are preponderantly minus, the medians of grades eleven and twelve are consistently on the plus side of 100. From this phase of the analysis a practical question arises: Are there actual differences in adjustment on the average between the different grades as wide as reflected by the values just cited? The following example bears on this point:

| | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | Mean of Diff. |
|---|---|---|---|---|---|---|---|---|
| Gr. 2 Mdn. | 95 | 97 | 91 | 97 | 95 | 92 | 94 | |
| Gr. 3 Mdn. | 102 | 105 | 106 | 105 | 106 | 104 | 106 | |
| Diff. of Mdn. | 7 | 8 | 15 | 8 | 11 | 12 | 12 | 10.4 |

Is the difference between these two groups as great as 10 adjustment points, the mean of the seven differences between the monthly medians? Further, are the differences in adjustment between grades ten and eleven and ten and twelve as conspicuous as is indicated by the comparative median adjustment scores? Within the limits of the present analysis no answer is available to these queries. An interpretation which suggests itself, however, is that the Yepsen technique may be not only an objective measure of social adjustment but likewise a key to the attitude of certain teachers toward pupils.

In order to picture compactly further tendencies of the frequency distributions the following elementary method of estimating skewness was adopted: for each series of seven medians (horizontal rows Tables 1 and 2) the median value was found; a similar procedure was followed in connection with each series of first and third quartiles and quartile deviations. To these basic values a formula cited by Arkin and Colton (2) was applied:

$$SK = \frac{(Q_3 - Mdn) - (Mdn - Q_1)}{Q}$$

Of the twenty indices of skewness seventeen were negative, two were positive, and one was zero. Considerable variability in the extent of skewness is noticeable. Following are the indices of skewness for the total distribution of pupils, each school, and grade for grade: total school population, -.21; school I, -.08; II, -.28; III, -.47; IV, -.12; V, -.19; VI, .11; grade 1, -.20; 2, -.19; 3, -.83; 4, -.35; 5, -.24; 6, .15; 7, -.13; 8, -.41; 9, -.18; 10, -.40; 11, -.18; 12, -.27; special .00. Of primary interest is the rather consistent manner in which adjustment scores tend to mass toward higher values.

An interesting sidelight which emerges from the present analysis is the practical question as to what adjustment score should be considered to be a crucial value, - i.e., a score below which a subject may be said reasonably to be unadjusted and, therefore, in need of specific therapeutic attention. Data do not give a direct answer to the question. Certain suggestions, however, may be made by inference. Yepsen (7) found with three separate tryouts of the Score Card mean scores of 53 and 47 for two groups of problem cases (boys) and 71 for a group of unstable girls. In the present analysis after the median was computed for each series of seven $Q_1$'s (horizontal rows Tables 1 and 2) the resulting values were found to range from 77 to 100, with the median value of the last mentioned series being approximately 85. This would seem to signify that so far as the present experimental situation is concerned an adjustment score of around 85 would be sufficient warrant for considering the individual subject as a problem in relation to the school group. The wide differences between the adjustment score just cited and those of Yepsen for known problem cases is probably due in part to differences in experimental conditions and attitude of raters. It should be remembered that practically all of the distributions are skewed toward high scores, a fact which would affect the values of $Q_1$. It would be exceedingly unwise to generalize from the present experimental situation on the basis of an adjustment score of 85. A much sounder procedure would be to establish criteria for each school population in terms of the nature of the subjects and predilections of the raters.

The final aspect of analysis deals with the problem of sex differences. To make this determination a random selection of cases was made. The adjustment scores for the month of January were used, since it was the middle month of the series of seven. The selection was made by tabulating the adjustment score of each third case irrespective of school attended, grade, race, age, or sex. From this procedure 615 cases resulted, 284 girls and 331 boys. Comparative medians, $Q_1$'s, $Q_3$'s, and Q's were computed. The related data are shown in Table 3.

TABLE 3

COMPARISON OF GIRLS AND BOYS ON YEPSEN ADJUSTMENT SCORES

| | Girls (N=284) | Boys (N=331) |
|---|---|---|
| Median | 103 | 99 |
| $Q_1$ | 92 | 79 |
| $Q_3$ | 116 | 113 |
| Q | 12.0 | 17.0 |

Medians show little difference between the sexes. Boys are more variable than girls in adjustment scores. While on the whole sex differences are not conspicuous, attention should be called to the difference of thirteen points between the $Q_1$'s for male and female subjects. This suggests the possible necessity for applying a different standard when adjudging lack of adjustment in boys as compared with girls.

CLINICAL IMPLICATIONS

One does not proceed far with the form of analysis undertaken without sensing

TABLE 4

MONTHLY YEPSEN ADJUSTMENT SCORES ON INDIVIDUAL CASES

| Case No. | Oct. | Nov. | Dec. | Jan. | Feb. | March | April |
|---|---|---|---|---|---|---|---|
| 1 | 118 | 97 | 84 | 110 | 123 | 128 | 121 |
| 2 | 148 | 147 | 148 | 148 | 148 | 147 | 148 |
| 3 | 105 | 106 | 117 | 76 | 100 | 96 | 96 |
| 4 | 98 | 110 | 94 | 107 | 91 | 100 | 66 |
| 5 | 105 | 95 | 122 | 95 | 100 | 104 | 113 |
| 6 | 69 | 63 | 89 | 87 | 95 | 81 | 72 |
| 7 | 121 | 106 | 96 | 100 | 106 | 113 | 106 |
| 8 | 41 | 39 | 56 | 59 | 51 | 45 | 52 |
| 9 | 83 | 91 | 98 | 76 | 57 | 62 | 70 |
| 10 | 138 | 130 | 130 | 129 | 137 | 145 | 125 |
| 11 | 59 | 50 | 59 | 51 | 51 | 56 | 47 |
| 12 | 133 | 130 | 130 | 138 | 144 | 137 | 145 |
| 13 | 84 | 115 | 126 | 123 | 137 | 136 | 120 |
| 14 | 86 | 90 | 69 | 102 | 79 | 54 | 86 |
| 15 | 92 | 102 | 92 | 109 | 106 | 90 | 118 |
| 16 | 41 | 52 | 36 | 56 | 57 | 45 | 45 |
| 17 | 138 | 140 | 138 | 142 | 135 | 142 | 148 |
| 18 | 90 | 69 | 74 | 100 | 85 | 61 | 58 |
| 19 | 60 | 59 | 79 | 82 | 73 | 90 | 97 |
| 20 | 40 | 34 | 38 | 31 | 42 | 57 | 56 |

that general statistical evaluations such as those employed here obscure much of the meaning of the data as it related to the individual. No set of facts is more convincing on this point that those displayed in Table 4.

In Table 4 is an array of individual cases which illustrate crucial points in adjustment. Some pupils maintain a markedly high level of adjustment throughout a seven months' period, as witness cases No. 2 and 12. Others have scores which are consistently in the direction of the lower end of the adjustment scale, cases No. 8, 16, and 20, for example. Certain individuals, such as case No. 5, maintain an average level of adjustment month after month. A considerable number fluctuate from month to month, e.g., cases No. 6, 9, and 18. The pupils cited in Table 4 are samples of variations in the adjustment picture as it occurs frequently among the 1838 pupils.

While nomothetic procedures designed to elicit general facts and principles are not without value, it seems rather clear that ultimately the problem of adjustment is one of individual rather than class differentiation. As stated so pithily by Allport: "The same fire that melts the butter, hardens the egg" (1, p. 325). Stated in other terms, adjustive responses in the school are of all degrees and varieties, but with no constant, uniform, or common cause in either the school situation itself or among individuals. The problem of dealing with pupils who are poorly adjusted, or improving the adjustment of those who are not palpable problems is one of analyzing the traits, dispositions, and motives of the individual pupil with reference to peculiarities of patterning and different forms of relationship. In fact, one of the uses which Yepsen (5) suggests for the Adjustment Score Card is just such clinical study of social adjustment.

## SUMMARY

Based on results obtained from the Yepsen Adjustment Score Card, 1838 pupils from a small town school system were studied. Monthly adjustment scores covering the school year from October to April were available in the survey. In the light of various aspects of statistical analysis it was found that in general adjustment scores are negatively skewed. The analysis failed to reveal signifi-

cant differences between the adjustment of white and negro children. Further, little or no difference on the average was found to exist between the sexes. Some evidence is adduced suggesting that adjustment scores may be affected by the attitude of the teacher toward pupils. Certain deficiencies of class analysis of pupil adjustment are indicated together with the intimation that the essential core of the problem of adjustment implies utilization of the clinical approach.

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# A BEHAVIOR SYNDROME CHARACTERIZING PREMATURELY-BORN CHILDREN

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Prematurely-born infants usually experience an initial arrest or delay in development during the early weeks after birth, but thereafter they resume growing at an accelerated rate that enables them eventually to overtake their term-born contemporaries in weight, height, and other physical features and in intellectual attainments. When prematures catch up with their birth age they are likely to vanish into the general child population, and the fact of their premature birth is no longer regarded as particularly significant in their behavioral development. The possibility that premature ejection of an individual into a world he has not yet grown up to fit may have lasting social and emotional consequences is an intriguing problem for the student of personality. Certainly the "seven-months baby" offers to the physiological psychologist an experimental animal somewhat comparable in neurophysical development to the pouch-young opossum and the experimentally delivered guinea-pig.

## FOLLOW-UP STUDIES ON PREMATURES

Vital statistics on prematures collected in several different countries indicate that about half of these babies die within the first year; but from one year on their death rate differs little from that of term-born children. During the past twenty years more than 3,000 surviving prematures have been located at ages ranging from 2 to 21 years; and measurements or estimates of their physical and mental status have been made. Most of the authors have confined their interest on the psychological side to the extent of mental defectiveness among prematures. Some of the varying answers to the question as to the proportion of prematures that are subnormal in intelligence are given in Table 1. Although in many cases it is impossible to tell what criteria the author used for subnormality, it is apparent that most of them have a definite bias on the question as to whether prematures differ from term children. The most optimistic investigators give the impression that prematures tend toward mental superiority; the least optimistic seem to consider them generally inferior. There is some evidence, particularly that of Rosanoff and Inman-Kane, that the effect of prematurity is to spread the distribution. These investigators, comparing their findings with those of Terman on unselected children, find a larger proportion of the prematures above IQ 115, and also a larger proportion below IQ 76. Their emphasis, however, is on the point that prematures contribute more than their share of cases to the institutional population.

## INCIDENTAL OBSERVATIONS ON PREMATURES

In contrast to the fairly consistent interest in the mental status of prematures, the interest in their behavior and personality characteristics has been scant. Such information as there is has been obtained merely by casual observation incident to the more precise measurement of physical or mental growth. A number of incidental observations are interesting and suggestive for further research. Capper (5) reports that 16 per cent of the prematures he examined, aged 4-19 years, were neuropathic, that 5 per cent were enuretic, and that 15 per cent (all under eight years) had speech defects. Ranke (22) believed that the number of neuropathic subjects was high in the group he studied. Embdin (8)

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TABLE 1

MENTAL STATUS OF PREMATURELY-BORN CHILDREN
(Arranged from the most to the least optimistic)

| Author | Date | Cases | Age Range | Mental Status |
|---|---|---|---|---|
| Comberg (7) | 1927 | 212 | 3-7 years | Mentality of the highest type |
| Osselman (19) | 1930 | ? | ? | No case mentally defective |
| Levy (15) | 1928 | 403 | 2-10 " | No marked tendency to mental defectiveness |
| Anon. (Leipzig) (1) | 1938 | 188 | 12-15 " | 34 per cent good; 46 per cent average; 19 per cent poor |
| Melcher (17) | 1937 | 42 | 2-18 months | 19 per cent above 120; 4.9 per cent below 80 |
| Rosanoff & Inman-Kane (24) | 1934 | 146 | Sch. age | 19 per cent above 115; 10 per cent below 76 |
| | | (Cf. Terman's unselected | | 11.5 per cent above 115; 2.6 per cent below 76) |
| Mohr & Bartelme (18) | 1930 | 113 | 8 months, 7 years | (Kuhlmann Binet) 1/5 above average; 2/5 average, 2/5 below (Gesell, 22 per cent above average; 43 per cent average, 35 per cent below |
| Sunde (31) | 1930 | 559 | 6-21 years | 7 per cent defective; 5.7 per cent feebleminded |
| Brander (2, 3) | 1937 | 376 | 7-15 | Direct relation between birth-weight and intelligence; below 1500 grm. no case of normal intelligence |
| Capper (5) | 1928 | 437 | Sch. age | 27 per cent 1 year behind, 20 per cent 2 years behind; 11 per cent feebleminded |
| Looft (16) | 1927 | 129 | " " | 24 per cent subnormal mentally |
| | | 105 | " " | 18 per cent subnormal mentally |
| Brandt (4) | 1923 | 292 | ? ? | Most of them below average physically and mentally |

reported more vomiting in premature than in term infants. Israel and Kemke (11) made the discovery that mortality for illegitimate prematures was greater than for legitimate prematures (55 per cent vs. 45 per cent). Leipzig (1) illegitimate prematures tended toward greater defective manifestations than legitimate prematures.

On the sensory side Peiper has reported that prematures react as readily as term infants to sound, light, pain, and cold stimuli. Catel found that eye-neck reflexes, auropalpebral reflexes, and caloric nystagmus, although variable in all neonates, were observed more frequently in prematures than in term infants.

Such a miscellany has little meaning unless the facts can be woven into the fabric of other research and fitted with an explanatory hypothesis. At the risk of adding further irrelevancies, this paper describes a constellation of traits that has crystallized more or less of its own accord out of incidental notes and cumulative observations made on premature babies and young children. The group of traits that is being introduced tentatively as a behavior syndrome characterizing prematurity has not been sought by precise experimental techniques, nor verified by laboratory methods. Instead it is entirely a by-product of developmental tests on premature babies and of play observations at later ages.

## SOURCE OF THE OBSERVATIONS

As a corollary to the study of 250 "normal" children that have been observed at regular intervals from birth onward, The Center for Child Health and Development, Harvard School of Public Health, also is following a group of prematurely-born children. These babies likewise come for periodic examinations at three-

month intervals up to 18 months and at six-month intervals thereafter. This group of 65 prematures ranged in age from 30 months down to 6 months at the time these observations were closed. They were subjected to the same type of observations made by the same group of examiners so that the records obtained on the premature series are entirely comparable to those on the normal series. Prematurity is defined for this group by the Boston Lying-In Hospital standard, - birthweight under 5 pounds. This group will be referred to as the younger prematures to distinguish them from a group of 30 premature children, ranging in age from 3½ to 6 years, that has been culled from the "normal series."

Contact with the younger prematures is limited to 221 Gesell-type examinations done at intervals of three months on these babies (25). Some babies had as many as six successive examinations, and more than half the group had four tests or more. Incidental notes on the mannerisms, emotionality, and social responsiveness of the babies at these tests furnish the material on the younger series. It may be mentioned in passing that all members of the staff have commented on the greater volatility and instability of the prematures in their emotional responses to examinations, and "premature day" is dreaded by those who are not actually engaged in the record taking.

The 30 cases culled from the "normal series" include all the cases satisfying two out of three criteria of prematurity, birthweight under 5 pounds, birthlength under 45 centimeters, and gestation period under 8½ months according to the doctor's calculation. On these children a complete series of mental tests from 3 months to their present age yields incidental information on behavior. In addition there are four all-day diary records on each child obtained on the occasion of the all-day visits to the Center for their regular examinations.

In addition to these 95 cases there were four cases of prematurely-born children among a group of 25 on whom the author made intensive observations more than ten years ago. Although no records of these children are included in this study, their behavior and development are very much in accord with the prematurity syndrome about to be described.

## THE PREMATURITY SYNDROME

The behavior syndrome will be described first in its entirety, beginning with the sensory and motor manifestations and proceeding to the emotional, social and intellectual features. Such quantitative data as are available will then be presented in support of it, with the full recognition that these data are inadequate because they represent mere gleanings rather than systematic experiments. Finally the possible neurophysical and social explanations of the syndrome will be considered.

Sensory acuity or interest: In auditory sensitivity the premature child either is more keenly aware of sounds or more interested in their meaning than the term child. Prematures are highly distracted by footfalls or voices in the corridor, by traffic noises, and by the sound of other babies crying on the floor below. There is some evidence that they very early attach meaning to sounds. Two 18-month premature boys, each of whom had been brought to the Center in a car, paused in the mental test to listen to the noise of a car being started on the street below, then slowly began to cry as if they feared they were being deserted; they were sitting on their mothers' laps at the time. A 3-year-old premature also cried at the sound of his mother's car starting; he was being left at the Center for the day. A 2-year-old premature girl cried at hearing the voice of the X-ray technician through a closed door; a half-hour earlier she had strenuously objected to the procedures involved in taking the roentgenographs.

Older premature children often manifest the "hark" response, - suddenly

stopping in their play and whispering in a startled voice, "What's that?" at the hiss of a radiator, a cricket chirp, or a fire siren two blocks away. One 3-year-old heard the thud of a book dropped on the floor above and exclaimed "That's a bomb!" Nothing could persuade him that it was not a bomb. A year later he announced at an unnoticed sound when the children were at their meal, "That's a machine gun! There are machine guns in that field and they might blow up that building."

On the visual-sensory side the premature babies were more fascinated and distracted by a yellow pencil than by any of the mental test objects, and the examiner often had to write with stubs she could conceal in her hand to keep the year-old baby from grabbing this bright object instead of the red blocks he was offered. A 5-year-old premature, filling a sheet with meaningless blobs of paint, said she was painting yellow pigeons, and asked, "Have you ever seen a yellow pigeon? I have; yellow pigeons, yellow pigeons at my door." In a biographical account of her earliest memories an adult premature mentioned tawny dogs, yellow cats, yellow flowers; in fact the only other color-word used was white. Another adult premature mentioned as the most beautiful scene of his childhood the sunlight on the yellow roofs of a Chinese city.

Premature babies and young children also seem to be more interested in ephemeral visual phenomena than term children, i.e., in shadows, smoke plumes, dancing motes in a sunbeam, reflections thrown by a mirror. The visual features of the syndrome, however, are the ones that are most doubtful, since they are the ones on which there are fewest incidental notes.

Lingual-motor control: In comprehension of speech the premature babies are quite as clever as term babies of the same intellectual level, and in attempts to utter words and to construct sentences the prematures show only slight retardation. But more prematures have difficulty in achieving correct pronunciation. They persist longer in baby-talk; and they often have letter substitutions, - pray for play; gwocks for blocks; tix for six. Often they utter long sentences that apparently are meaningful, but only one or two words can be distinguished in the jumble. The difficulties of the little Dionne girls in learning to talk intelligible French probably are only slightly greater than those of many prematurely-born children.

Manual-motor control: In manual activities and fine motor control the premature is retarded a number of weeks. Retardation is particularly noticeable in the use of the index finger for pointing, and for pincer grasp. A number of prematures have stubby, spade-like hands with the third and fourth digits closely approximating one another in length. In several prematures peculiar gestures with the hand - flipper or paddle-like gestures - have been noted. Prehension often is carried out with all four digits opposing the thumb, rather than merely with thumb and index finger, which is more commonly used by term babies.

In addition the premature children, young babies and older ones, exhibit characteristic gestures. Often after prolonged effort to reach they exhibit tremor. Their play with toys is executed with choppy, slap-dash movements. They over-reach, spill, scatter; and prematures of 12 and 18 months have a passion for throwing toys to the floor or brushing them aside with petulant gestures. Often they achieve a high degree of skill with prolonged and persistent effort, as in filling a Wallin peg-board at 18 months, or in building complicated block structures at 5 years. Sometimes prematures work at such a task, exerting the utmost effort to make the precise coordinations, until their reserve of patience and nervous control is at an end and they "go all to pieces."

Postural and locomotor control develop later in premature than in term children, and once the premature achieves ambulation, he usually is less graceful and less smoothly-flowing in his motor responses than the term child. Our older prematures are more often described as awkward, clumsy, as having a lunging gait,

or as having poor posture, than our term children.

Activity: In amount of activity premature children seem to go to two extremes. On the one hand are tense, jumpy, hyperactive little creatures that seem to be mounted on springs; and on the other are floppy, soggy, lazy babies and sluggish, clumsy children, slow and deliberate in their motions.

Sphincter control: The achievement of bowel and bladder control is slower and more difficult in premature than in term-born children. Enuresis, day dribbling, and high urinary frequency are more common among prematures.

Emotionality: Emotionally the premature child is more irascible, petulant, and more often shy and negativistic than the term child. Prematures are upset by slighter stimuli; they are capable of standing just so much, then they explode in a tantrum or a panic. More of them hide their faces in the mother's bosom, and sometimes they appear to comprehend perfectly what the examiner wishes them to do, but they actively inhibit their genuine desire to comply. They reach tentatively, then withdraw from the proffered object. Often they are enraged at having a toy taken away from them, even though they are offered an equally attractive one at the same time; and it is sometimes necessary to allow them to carry a toy with them in order to get them to leave the testing room without an outburst.

Sociality: The premature often is shy and very much attached to the mother. He is prone to seek help from her or from any friendly adult when he encounters a slight difficulty, appealing to have things done that he could do or could readily learn to do for himself. An 18-month baby had with considerable effort placed five pegs in a board, but he begged the examiner to place the sixth one, placing her hand over the peg. When she refused to help him he handed the peg to his mother. Another baby placed two blocks in a form-board, but handed the third to his father to be inserted.

Attention: The attention-span of the premature is very short; he flits from toy to toy in the playroom; and at the test situation he is extremely susceptible to distractions. It often is difficult to get him to stick to a difficult task and to see it through, particularly if it is possible for him to appeal for adult help in finishing it. Conversely, - and this seems a contradiction, - the premature sometimes works to the point of nervous exhaustion on a difficult motor coordination. He continues working at a high level of interest and concentration until he collapses in rage from fatigue and frustration.

Aesthetic appreciation: Aesthetically the premature children seem to have an appreciation of the beautiful and a desire to create artistically. Many of them demand to paint, but their motor coordinations are so poor that their paintings are mere meaningless blobs. One or two of the older ones have produced quite surrealistic effects in their paintings.

## QUANTITATIVE OBSERVATIONS

The above generalized statements are based on the author's long acquaintance with the accomplishments and abilities of term-born children. For the purpose of quantitative comparisons each premature child was matched with a term-born child of the same age, sex, and position in the family constellation. In Tables 2 and 3 the percentage of premature infants and children manifesting any given item is compared with the percentage for controls.

It must be remembered that none of these items was consistently looked for in either the premature or the term group. These are just chance observations and incidental notes that happened to have been recorded at the mental examinations or the all-day observations; and they were ferreted out only after the records had been reposing in the files for several months. The differences between prematures and controls is small in some items, and in most instances they

TABLE 2

PREMATURITY SYNDROME AS OBSERVED AT MENTAL EXAMINATIONS

| Younger Group (6-24 mo.) | 50 Prematures Per cent frequency | 50 Controls Per cent frequency |
|---|---|---|
| Interest in yellow pencil | 16 | 0 |
| Distracted by sounds | 36 | 6 |
| Paddle gestures | 8 | 2 |
| Petulant gestures | 2 | 0 |
| Throwing toys to floor | 30 | 6 |
| Banging, slapping toys | 20 | 10 |
| Motor persistence | 16 | 10 |
| Tremble, shudder, jittery | 18 | 10 |
| Sleepy, lazy | 20 | 10 |
| Cry when toy is removed | 16 | 10 |
| "Nervous" | 12 | 0 |
| Shy | 28 | 24 |
| Hesitate to touch toys | 10 | 12 |
| Seek adult help | 22 | 6 |
| Comprehend but refuse to perform | 18 | 8 |
| Withdraw instead of reach | 12 | 2 |
| **Older Group (2½-5 yrs.)** | **22 Prematures Per cent frequency** | **22 Controls Per cent frequency** |
| Shy | 50 | 37 |
| Very distractible | 45 | 13 |
| Distracted by sounds | 18 | 4 |
| Short attention span | 13 | 9 |
| Cry; impossible to test | 32 | 23 |
| Throwing toys to floor | 13 | 9 |
| Tremble | 9 | 4 |
| Give up easily, discouraged | 18 | 0 |

TABLE 3

PREMATURITY SYNDROME MANIFESTED DURING PLAY PERIOD

| Older Group Only (2½-5 yrs.) | 30 Prematures Per cent frequency | 30 Controls Per cent frequency |
|---|---|---|
| Remarks about unusual sounds | 67 | 37 |
| Speech difficulties | 60 | 23 |
| Cry in the playroom | 80 | 57 |
| Cry at examinations | 60 | 77 |
| Attention to crying of other children | 37 | 20 |
| Rapid change from toy to toy | 43 | 23 |
| Scattering toys | 23 | 17 |
| Seeking help | 43 | 17 |
| Giving up, discouraged | 27 | 10 |
| Jittery, nervous | 83 | 27 |
| Bowel movement at Center | 40 | 30 |
| Five or more urinations | 27 | 12 |

Proclivity for Asking Questions

| Ages | Median number of questions in 30 min. Boys Premature | Boys Control | Girls Premature | Girls Control |
|---|---|---|---|---|
| 2½ | 4 | .5 | 4 | 0 |
| 3 | 11 | 3 | 6 | 11 |
| 3½ | 9 | 4 | 11 | 15.5 |
| 4 | 3.5 | 0 | 13.5 | 5 |
| 4½ | 7 | 3.5 | 6 | 1.5 |
| 5 | 5.5 | 2 | 6 | 4.5 |
| 5½ | 5.5 | 0 | 5 | 11 |
| 6 | 6 | 0 | 11 | 0 |

would not meet the criteria for statistical significance because of the small number of cases. But for the most part the results are consistent for the older and the younger group; and for the mental test observations and those made during the all-day visit. Certainly response to auditory stimuli, throwing or scattering toys, seeking help, giving up in discouragement, "nervousness" and short attention span show a greater percentage frequency for prematures than for controls in each table.

In Table 3 it appears that more prematures cry in the playroom than at the examinations, whereas more controls cry at the examinations than in the playroom. This might seem paradoxical were there not other evidence to indicate that crying in the playroom represents greater emotional insecurity than crying at examinations. Crying in the playroom is attributable mostly to loneliness and desire for the mother; whereas crying at examinations is occasioned largely by the child's distaste for the examining procedure. Consequently this reversal in amount of crying of prematures and controls again bears out the point that prematures are more mother-dependent than term children.

Having a bowel movement or a number of bowel movements at the Center was somewhat indicative of emotional upset. There was a sex difference in this item. Among premature boys the percentage having bowel movements at the Center was 41.5, and only 21.6 for controls. For girls there was no difference; 39 per cent of prematures and 39 per cent of controls had movements at the Center. In the matter of bowel movements premature boys are more like premature and control girls than they are like control boys. In urinary frequency, however, the difference is between prematures and controls rather than between sexes; of premature boys, 28 per cent, girls 27 per cent; control boys 12 per cent, girls, 11.5 per cent urinate five or more times on their day at the Center.

Prematures differ from controls also in their proclivity for asking questions. The median number of questions asked during a 30-minute period in the playroom was consistently higher for premature boys than for their controls; for girls the differences were not so consistent, but at most age levels the premature girls were more inquiring than the controls. Questioning is a well-recognized attention-getting device among preschool children. The tendency to ask questions is consistent with the prematures' dependence on adults and their desire to seek help.

Table 4 indicates the extent to which these manifestations can be considered a syndrome. It shows that the items do tend to hang together in a pattern when individual prematures are considered. The pattern is more consistent for premature boys than for premature girls. This fact is consistent with the general findings of other investigators who have observed that boys suffer more than girls from prematurity, whether the measure is in terms of mortality or of cerebral injury or of congenital defects.

## CONFIRMATORY EVIDENCE FOR THE SYNDROME

The syndrome as outlined in Table 4 has considerable confirmation from the literature on prematures. The responsiveness of newborn prematures to auditory stimulation has been noted by Peiper (20) and by Catel (6). Ray (23) observed that the human fetus became active so consistently in response to auditory stimulation that he contemplated trying to condition the unborn child to a sound. Sontag and Wallace (27) found a reliable increase in fetal movements in response to a doorbell buzzer; responsiveness to sound began in the 31st week of intrauterine life and increased in magnitude as the fetus neared term. The research of Streeter (30) on the development of the acoustic nerve in humans, and that of Larsell, McCrady, and Zimmerman on the pouch young opossum is further evidence that in both human and animal fetus the ear is functionally complete both in

TABLE 4

INDIVIDUAL MANIFESTATIONS OF SYNDROME

| | Keen audition | Speech difficulty | Choppy gestures | Hyperactive | Clumsy or cautious locomotion | Rapid change of toys | Scatters toys | Seek help | Wriggle at exams | Fears lying on high table | Trembles | Jittery, "nervous" | Worrying, flighty or "neurotic" |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Premature Boys | | | | | | | | | | | | | |
| 88 | x | x | | | x | x | | x | | | x | | |
| 94 | x | x | x | x | | x | | | x | | | x | |
| 95 | | x | x | x | | x | | | x | | | x | |
| 106 | x | x | x | x | x | x | | | x | | | x | |
| 107 | x | x | x | x | x | x | | | x | | | x | |
| 158 | x | x | x | x | | x | | | | x | | | |
| 179 | x | x | x | | x | x | | x | | x | | x | |
| 186 | | x | x | x | x | x | x | | | | | | |
| 191 | x | | | x | x | x | x | x | x | | | | |
| 196 | x | x | x | x | x | x | x | | x | | | | |
| 203 | x | | | x | x | x | | x | | x | x | x | |
| 211 | x | | | x | x | x | x | x | | x | | x | |
| 228 | x | x | x | x | x | x | x | x | x | | | | |
| Premature Girls | | | | | | | | | | | | | |
| 87 | | x | x | | | x | | x | x | x | x | x | x |
| 92 | x | | | x | x | x | | | | | | | |
| 112 | | | x | | x | x | | | | | x | | x |
| 120 | | | | x | | x | | x | x | | | | x |
| 122 | x | x | x | | x | x | | | x | x | | x | |
| 125 | x | | | | | | | | x | | | x | |
| 135 | x | x | | | x | x | | | | | | | |
| 168 | x | x | | | | x | | x | | x | | | |
| 169 | | x | | | | x | | | | | | | |
| 180 | | x | | | | x | | x | | | | x | |
| 181 | | x | | | | x | | x | | | | x | |
| 206 | x | | | | | | | | x | | | | |
| 232 | x | x | | | x | x | x | x | x | | | | |
| 233 | x | x | | | x | x | x | x | x | | | | |

anatomical structure and in its nerve supply long before birth.

Investigation on visual sensitivity cannot be carried out on the fetus in utero, but it is well recognized that the yellow-blue visual area is phylogenetically older than the red-green area. Staples (29) found that infants under 6 months were more responsive to yellow than to the other primary colors even when brightness values were controlled.

Concerning speech difficulties in prematures, Comberg (7) admits that there is a delay in age of talking, but attributes it to lack of tone rather than to lasting cerebral injury. Capper (5) reported 7 lispers, 2 stutterers, 1 case of nasal speech, and 4 children having difficulties with the letters l and n among his 97 cases. Mohr and Bartelme (9, p. 206) found speech difficulties in 9 per cent of the prematures and in 9 per cent of their sibling controls, but state that the incidence is really greater among prematures because some of them had not yet reached the age of talking. There were 9 stutterers among the prematures as compared to 3 among controls.

Difficulties in manual control and fine motor coordination are not reported

by other authors, although Mohr and Bartelme found that 38 of the prematures were predominately left-handed.

Delay in the static development of prematures is well recognized and is mentioned by Comberg (7), Capper (5) and Levy (15). Mohr and Bartelme (9) found that prematures sat alone about two months later and walked almost three months later than their term-born siblings. The delay in walking was greater in boys than in girls. The delay was reduced but not entirely effaced by subtracting from the birth-ages of prematures the amount of their prematurity.

Delay or difficulty in the establishment of sphincter control also was observed by Mohr and Bartelme (9, p. 203). Again the delay was greater for boy than for girl prematures.

Few authors consider the emotionality and sociality of the prematurely-born. Mohr and Bartelme (9, pp. 209-217) made an effort to obtain information on the personalities of prematures. More than 20 per cent of their premature group persisted in thumb-sucking beyond the age of 28½ months. At the mental test they also noted reactions of dependency on the mother similar to those described for the Boston prematures, - hiding the head in the mother's lap, clinging to her, and turning to her for help or approval. At the test situation the prematures manifested decidedly more outbursts of temper, banging, throwing, kicking, biting, and screaming, than their term-born siblings. Premature boys displayed more temper than the girls, whereas the girls displayed more stubbornness, passive resistence, and negativism. Prematures were also more fearful of persons and animals than their siblings, but the siblings showed more fear reactions of other types.

TABLE 5

TRAITS IN WHICH PREMATURES DIFFERED FROM SIBLINGS BY 10 PER CENT OR MORE
(Adapted from Mohr and Bartelme, 9, p. 215)

| | Youngest<br>2½ yrs. and below | Middle<br>2½ to 5½ yrs. | Oldest<br>Above 5½ yrs. |
|---|---|---|---|
| Activity: | hyperactive | *lazy | alert |
| Sociability: | friendly<br>poor mixers<br>timid<br>responsive to adults | sociable<br>friendly<br>*good mixers<br>shy<br>responsive to older children | withdrawn<br>*unresponsive to adults |
| Family relations: | unselfish<br>*unaffectionate<br>*poor response to sibling<br>quarrelsome | *poor response to sibling<br>jealous | affectionate<br>*poor response to sibling<br>jealous |
| Dependence: | | self-reliant<br>*show-off | not self-reliant<br>show-off<br>demanding<br>attention demanding<br>*dependent |
| Discipline: | less good natured | spoiled | obedient |
| Negativism: | | contrary<br>*stubborn<br>not submissive | aggressive |

*In items marked with a star prematures exceeded their siblings by 20 per cent or more.

These authors also obtained mothers' reports on certain personality traits in prematures and their siblings. They present the material only in graphic form, one chart for siblings and one for prematures, (9, p. 215) so that direct comparisons are hard to make. The authors call attention to only two differences; fewer prematures are said to get along well with their siblings; and fewer are said to be sociable. A reworking of the authors' data, however, yields somewhat different results from those they report. The material of the charts was converted back into percentage tables by reading the points as accurately as possible. Differences in percentage were then obtained between prematures and siblings for each of the items at each of the three age levels. Table 5 lists the traits in which prematures and siblings differed by 10 per cent or more; differences of 20 per cent or more are starred. Some of the differences are ambiguous or contradictory from one age to another. But the indications are that in family relations prematures differ from their siblings in being more jealous, less good to the siblings, and in making more demands for attention, showing off, and in being dependent and less self-reliant as they grow older. In general prematures seem to try to preserve their status as over-protected and over-cared-for members of the family group.

Further evidence of the emotionality of prematures is furnished by a report of infants surviving a low weight of 1000 grams or less (9, pp. 221-239). Of the 18 infants included in this group, 8 were above 18 months of age, and some personality characteristics were reported for them. The personality notations are given in Table 6. For cases 13 and 14 the traits reported are all desirable. All other cases show emotional instability of some sort, - timidity, stubbornness, or tantrums. Sensitivity and high imagination are reported for two of the cases.

TABLE 6

NOTES ON THE PERSONALITIES OF EIGHT PREMATURES SURVIVING A LOW WEIGHT OF 1000 GRAMS
From Kunstadter and Bartelme (9, 221-239)

| Case | Age | Personality notations |
|---|---|---|
| 1. SI | 6 years | Fussy about foods; shy, timid, dependent, evades difficult tasks, withdrawn, insecure; stubborn, unstable; very imaginative, inventing stories and expressing herself in drawing. |
| 2. NW | 6½ " | Poor appetite; happy, active, cheerful; gets along well with twin and likes other children better; less good natured than twin; more aggressive, likes to show off; more babyish than twin. |
| 5. RF | 2 " | Must be fed, vomits if forced; happy and generally good natured; shy of strangers, stubborn, spoiled, and overindulged. |
| 6. RD | 19 months | Not finicky about food; happy, rather sensitive; somewhat spoiled; alert and responsive, though moderately timid; occasionally has tantrums. |
| 7. JW | 4 years | Slow in development of speech and untrained in toilet; hyperactive and unstable; attention labile; cries and exhibits temper. |
| 13. FS | 2 " | Happy, quite independent, very active; learning to protect himself from older sister, a prematurely born child who was dependent, spoiled, and who attempts to dominate him. |
| 14. BA | 5 " | Fed by mother till age 4 though able to feed self at 3; sometimes has to be coaxed to eat. Self-confident, self-reliant; very active, rather aggressive, happy, obedient. |
| 17. PM | 22 months | Not finicky about food. Stubborn, resistant, has tantrums; more aggressive than twin sister; poorly trained. |

## INTERPRETATION OF THE SYNDROME

In view of the tentative character of the observational data it is perhaps unwise to speculate as to the probable causes, or the neurophysical correlates of the behavior syndrome that seem to characterize the prematurely-born individual. Nevertheless it is worth while to review briefly a few of the differences between term and pre-term infants and to consider whether some of the behavior differences are not a logical outgrowth of these differences. Toxemia of pregnancy and multiple pregnancies are common causes of premature birth. Under both these conditions the premature is subjected to a less favorable prenatal environment than the term child. Rosanoff (24) has attempted to distinguish between pre-germinal, germinal, embryonic, fetal, and natal factors in the etiology of mental deficiency; the operation of any of these factors unfavorably might lead to congenital defects, but only the pre-germinal influences can, in Rosanoff's opinion, be considered truly hereditary.

Term birth is preceded by several physiological preparatory responses on the part of the fetus. One of these is an increased red cell content of the blood. Even more well-known are certain glandular hypertrophies, particularly of the gonads and of the adrenals. In term babies, the cortex of the adrenal gland, which recently has been shown to play an important role in potassium metabolism, (34) which, in turn, plays an important role in neural conductivity, has already developed a row of well-nucleated cells enveloping the medulla; whereas in prematures this degree of development is not complete.[2] Certainly one of the premature's many privations is the loss of a rich hormonal medium furnished by the maternal circulation in late pregnancy.

Premature births often are cataclysmic; unduly prolonged or precipitant, both of which conditions subjects the baby to birth trauma. At birth the premature suffers a more prolonged weight loss, and an arrest in development that writes its permanent record in the growth of the bones; may it not also write a permanent record in that much more plastic tissue, the nervous system? Thus it seems possible that, through a less favorable prenatal environment, or through the too early loss of intra-uterine media, or through the lack of adequate time for the birth preparatory responses, or through birth injuries that sometimes are so slight as to be unrecognized or through a combination of these factors, the premature may be predisposed toward the development of a higher degree of nervous irritability than the term child.

Much of the behavior of prematures becomes understandable if we assume that he is more sensory than he is motor. There is good evidence that his sensory development is in advance of his motor control, age for age. The premature is highly receptive to stimulation, particularly to auditory stimulation; but he is less capable than the term child of making an adequate motor adjustment to the stimulus. He is, in the words of Browning, a person whose "reach exceeds his grasp". The frustration that comes from inability to manipulate materials may well become a source of irascibility that is expressed in petulancy and in the tendency to throw or scatter toys. Such a condition might well lead to habits of inattention, flitting interest in toys, and subsequently to versatility in interests and the development of many hobbies, - a trait that seems to characterize adult prematures. Prolonged effort at precise coordination may lead to a real neuromuscular fatigue that suddenly sends the premature baby into an emotional paroxysm. The prematures' stubborn refusals, their withdrawals from proffered toys, and their tendency to give up a task before its completion may be a way of reducing the amount of stimulation they receive. Superior sensory ability, i.e., sensory ability that exceeds motor ability, might also lead to certain types of aesthetic appreciation that seem to crop out often among

[2] *Information obtained in conference with Dr. R. L. Zwemer.*

prematures. Indeed the word "sensitive" as used by the layman begins to take on a literal meaning when applied to the premature.

Prematures also differ markedly from term children in their postnatal environment. They are both more deprived and more protected than term babies. In the early weeks they are more isolated from human contacts, and for months they are watched over with more solicitude. Most mothers go to extremes first of under-stimulation, and later, when the baby has "caught up" in physical size, of over-stimulation in the hope that he now is able to erase every discrepancy between himself and his term contemporaries. Such conditions quite logically might lead to greater dependence on the mother and to shyness and withdrawal from other adults. Poor motor capacity combined with high maternal solicitude may explain the premature's greater tendency to seek help from adults in minor difficulties and to give up readily in the face of slight adversity. The family environment in which the prematurely-born child spends his early years is quite adequate to account for most of the social and emotional differences of prematures.

The prematurely-born child also seems to serve as a test case for several of the psychoanalytical concepts. In a truly literal sense the premature is a "rejected" child; he is biologically rejected, or ejected from the womb before he has had his fill of its tranquil pleasures, as the psychoanalysts so picturesquely put it, more precisely before he has fulfilled his physical growth needs. Therefore the premature might legitimately desire to retreat to the womb, a theory psychoanalysts have used to explain humans' liking for cozy corners and secluded nooks. It has been observed both by Mohr and Bartelme and by me that premature babies are more prone to hide their faces in the mother's lap and that they more readily withdraw.

Prematures are more often deprived of the breast than term children. According to the observations of psychoanalysts this might lead to more oral habits in prematures than in term children. In substantiation of this Mohr and Bartelme report more thumb-sucking in prematures.

Difficulty in achieving sphincteral control, which is unquestionably greater for prematures, might, according to psychoanalytic theory, lead to emotional complications with regard to excretory functions, and perhaps to arrest on a uro-anal level. The children in the present group are too young for enuresis to have become overlaid with feelings of guilt or with parent-thwarting emotional significance, but the overcoming of this habit bears further study.

## SUMMARY

Prematurely-born babies and preschool children manifest a behavior syndrome, the essential features of which are: keen auditory and visual sensitivity or interest; lingual-motor, manual, and locomotor difficulties manifested by speech difficulties, choppy, slap-dash manipulation, and lunging, clumsy gait or overcaution in motor pursuits; hyperactivity or sluggishness and occasional tremor; difficulties in sphincter control. Emotional and social features of the syndrome are: short, flitting attention; high susceptibility to distractions; high irascibility; stubbornness and negativism; shyness and overdependence on the mother; and possibly high and versatile aesthetic interests. Boys manifest the syndrome somewhat more completely than girls. The syndrome has support from the literature on premature children. The possible roles of prenatal factors and postnatal environment and training in the etiology of the syndrome are discussed.

Although it is not implied that children who manifest one or more features of the syndrome probably are prematures, yet it is suggested that a search of the histories of such children might reveal prenatal or postnatal conditions similar to those for prematures. Careful comparison of a group of prematures

with a group of term children manifesting several features of the syndrome should reveal which aspects of the syndrome are attributable to prematurity per se and which are attributable to other factors usually associated with the care and training of prematures. In any case prematures are excellent subjects in which to study some fundamental personality traits.

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# LENGTH OF HEAD AND NECK, TRUNK, AND LOWER EXTREMITIES ON IOWA CITY CHILDREN AGED SEVEN TO SEVENTEEN YEARS

HOWARD V. MEREDITH[1]

It is the purpose of this paper to report an investigation into the growth of the three major components of human stature during the age period from seven to seventeen years. The report includes 1) tables, specific for sex and one-year age groupings, giving central tendency and variability values for head and neck length, trunk length, and leg length,[2] 2) graphic comparison of the mean trends for males and females in each of the three dimensions, 3) tabular and graphic presentation of the mean findings for each dimension at successive ages expressed as percentages of mean stature at corresponding ages, and 4) quantitative analysis of the interrelation of the three dimensions - using both an approach of mass statistics (correlation coefficients) and an approach of individual statistics (percentile rankings for specific subjects).

## MEASUREMENTS

Trunk length was taken as a direct measurement. Head and neck length and leg length were each obtained as derived dimensions - the former as stem length minus trunk length and the latter as stature minus stem length. The anthropometric technique employed in securing the measurements of stature, stem length, and trunk length was as follows:

Stature: The instruments used were the Baldwin Paper Measuring Scale and Square. The subject stood erect with heels almost touching each other. Heels, buttock, upper part of back, and rear of head were against the wall to which the scale was attached. The arms were permitted to hang at the sides of the body in a natural position, the heels were in firm contact with the floor, and the head was oriented with the Frankfort Horizontal at right angles to the long axis of the body. One face of the square was so placed against the scale that the other face was parallel with the floor. The anthropometrist then brought down the square upon the vertex (using sufficient pressure to crush the subject's hair) and made the reading.

Stem Length: The instruments were the same as for stature. The subject sat erect on a horizontal walnut bench 30 centimeters in height. His knees were flexed and spread apart, his ankles crossed, and his hands rested upon his thighs. The posterior aspect of the trunk made contact with the scale both at the sacral region and at the thoracic region. The square was brought down firmly upon the vertex (the highest point of the head when held with the Frankfort Horizontal at right angles to the body axis) and the measurement recorded as the distance from this point to the surface of the bench.

Trunk Length: The instrument used was the lower half of the Martin Tubular Anthropometer. The subject maintained the position assumed for taking stem length. The lower half of the anthropometer was placed perpendicular to the surface of the bench, its base resting on the bench near the center of its anterior edge. The sliding arm of the anthropometer was then brought down on the supersternale (the highest point of the sternal notch in the median plane)

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[2] *Throughout this paper "leg length" will be used synonymously with "length of lower extremities." This substitution of popular for anatomically correct terminology is made solely on the ground that in discussing the findings of the study it was found less cumbersome to make repeated use of the term "leg length" than the term "length of lower extremities."*

and the measurement recorded as the distance from this point to the surface of the bench.

## DATA

The basis data consist of approximately 2,700 values each for stature, stem length, and trunk length. These data were obtained from measurement of roughly 740 children attending the University of Iowa elementary school and high school. They represent observations accumulated during the years 1929 to 1937 by the anthropometric staff of the Iowa Child Welfare Research Station.

The children ranged in age between six years, six months and seventeen years, five months, thirty days. Many of them had repeated measurement records extending over a period of four to six years. They were about equally divided as to sex.

In tabulating these data, each record was taken from the files in serial order. Those records were accepted for use that 1) fell between the age limits of the study, 2) carried values obtained at one examination for the three dimensions required, and 3) were not marked as applying to individuals of Negroid, Mongoloid, Jewish, or southwest European stock, or to individuals considered to lie outside the normal zone for physical build.

Information on country of birth of the parents and grandparents and on occupation of the father was available for approximately 45 per cent of the subjects. Analysis of the available material on these items yielded the following findings:

1. Both parents for more than 95 per cent of the subjects were born in the United States.

2. For approximately 60 per cent of the subjects, the parents and four grandparents were all born in the United States.

3. Roughly 40 per cent of the fathers were professional people, and an additional 25 per cent were business proprietors, managers, or salesmen. About 15 per cent were farmers, though this occupation was not evenly distributed over the age range studied.[3] The remaining 20 per cent were largely skilled trade employees.

The sample employed may be summarily characterized as being homogeneous with respect to geographic location, consisting of North American-born children of northwest European ancestry, and representing a population heavily weighted with the professional and managerial classes.

## HEAD AND NECK LENGTH

A total of 2,735 head and neck length values, derived as stem length minus trunk length, were analyzed. Roughly one-half (1,344) were for males and the remaining 1,391 for females.

The values for each sex were first reduced to eleven frequency distributions covering the successive annual age intervals from six years, six months to seventeen years, five months, thirty days. From the resulting twenty-two distributions, the eight columns of figures were obtained that are presented in Table 1. Selected findings from this table are:

1. Mean head and neck length, both sexes combined, is approximately 26.1 cms., or 10.3 in., at 7 years of age; 29.7 cms., or 11.7 in., at 13 years of age; and 31.4 cms., or 12.4 in., at 17 years of age.

2. For males, mean head and neck length is 26.5 cms. at 7 years, 29.6 cms.

[3] *About four-fifths of the children whose fathers were farmers attended the University of Iowa high school without being previously enrolled in its elementary school.*

TABLE 1

HEAD AND NECK LENGTH (CENTIMETERS): MEAN, STANDARD DEVIATION, COEFFICIENT OF VARIATION, LIMITS OF INTERQUARTILE RANGE, AND RANGE AT ANNUAL AGE INTERVALS FROM SEVEN TO SEVENTEEN YEARS

| Mean Age, Years | Cases | Mean | Standard Deviation | Coefficient of Variation | 25th Percentile | 75th Percentile | Range |
|---|---|---|---|---|---|---|---|
| | | | | Males | | | |
| 7 | 113 | 26.5 | 1.4 | 5.2 | 25.5 | 27.3 | 23.4 to 29.8 |
| 8 | 107 | 27.0 | 1.1 | 4.1 | 26.3 | 27.7 | 23.8 to 30.1 |
| 9 | 103 | 27.6 | 1.3 | 4.6 | 26.8 | 28.4 | 24.3 to 30.8 |
| 10 | 105 | 28.1 | 1.3 | 4.5 | 27.3 | 28.9 | 24.9 to 31.1 |
| 11 | 96 | 28.4 | 1.4 | 5.0 | 27.3 | 29.5 | 24.8 to 31.6 |
| 12 | 90 | 28.9 | 1.3 | 4.6 | 28.0 | 29.7 | 25.4 to 32.4 |
| 13 | 103 | 29.6 | 1.6 | 5.5 | 28.3 | 30.8 | 25.9 to 33.4 |
| 14 | 138 | 30.3 | 1.6 | 5.3 | 29.1 | 31.3 | 26.1 to 34.6 |
| 15 | 163 | 31.0 | 1.9 | 6.0 | 29.8 | 32.0 | 26.3 to 35.9 |
| 16 | 172 | 31.8 | 1.7 | 5.4 | 30.6 | 33.0 | 27.1 to 36.2 |
| 17 | 154 | 32.2 | 1.7 | 5.4 | 30.8 | 33.5 | 27.6 to 36.9 |
| | | | | Females | | | |
| 7 | 107 | 25.7 | 1.2 | 4.7 | 25.0 | 26.6 | 21.9 to 29.1 |
| 8 | 100 | 26.2 | 1.3 | 4.8 | 25.4 | 27.0 | 22.4 to 29.5 |
| 9 | 95 | 26.8 | 1.1 | 4.1 | 26.0 | 27.6 | 24.6 to 29.8 |
| 10 | 116 | 27.4 | 1.4 | 5.3 | 26.7 | 28.2 | 24.4 to 31.2 |
| 11 | 113 | 28.2 | 1.4 | 5.0 | 27.3 | 29.0 | 24.5 to 31.7 |
| 12 | 120 | 28.8 | 1.7 | 5.8 | 27.7 | 29.9 | 24.4 to 33.6 |
| 13 | 114 | 29.7 | 1.7 | 5.8 | 28.7 | 30.9 | 24.7 to 33.7 |
| 14 | 154 | 30.1 | 1.6 | 5.2 | 29.1 | 31.2 | 25.3 to 33.8 |
| 15 | 165 | 30.4 | 1.7 | 5.6 | 29.5 | 31.6 | 25.2 to 34.3 |
| 16 | 155 | 30.5 | 1.6 | 5.4 | 29.5 | 31.7 | 25.5 to 34.3 |
| 17 | 152 | 30.5 | 1.5 | 4.9 | 29.8 | 31.6 | 26.0 to 34.0 |

at 13 years, and 32.2 cms. at 17 years. For females, means at corresponding ages are 25.7 cms., 29.7 cms., and 30.5 cms.

3. Means at 13 years exceed means at 7 years by 3.1 cms., or 11.7 per cent, in the case of males and by 4.0 cms., or 15.6 per cent, in the case of females. Means at 17 years exceed means at 7 years by 5.7 cms., or 21.5 per cent, for males and by 4.8 cms., or 18.7 per cent, for females.

4. In relation to mean size at 17 years, the means at 7 and 13 years, respectively, are equivalent to 82 per cent and 92 per cent for males and to 84 per cent and 97 per cent for females.

5. Head and neck length means for males exceed those for females at all ages studied except 13 years. The amount of excess is 0.8 cms. between 7 and 10 years, 1.3 cms. at 16 years, and 1.7 cms. at 17 years. (See Figure 1, Section C).

6. The standard deviations fall within the limits of 1.1 cms. and 1.9 cms. Over the age period from 7 to 11 years the mean standard deviation is 1.3 cms. for each sex. From 13 to 17 years the mean standard deviation is 1.6 cms. for females and 1.7 cms. for males. Identical figures for each sex are obtained at 11 and 14 years. The most divergent values (1.3 cms. for males and 1.7 cms. for females) occur at 12 years.

7. Coefficients of variation fluctuate between 4.1 per cent and 6.0 per cent. Identical values for the two sexes are obtained at 11 years and at 16 years. At 12 years the male coefficient stands at 4.6 per cent and the female

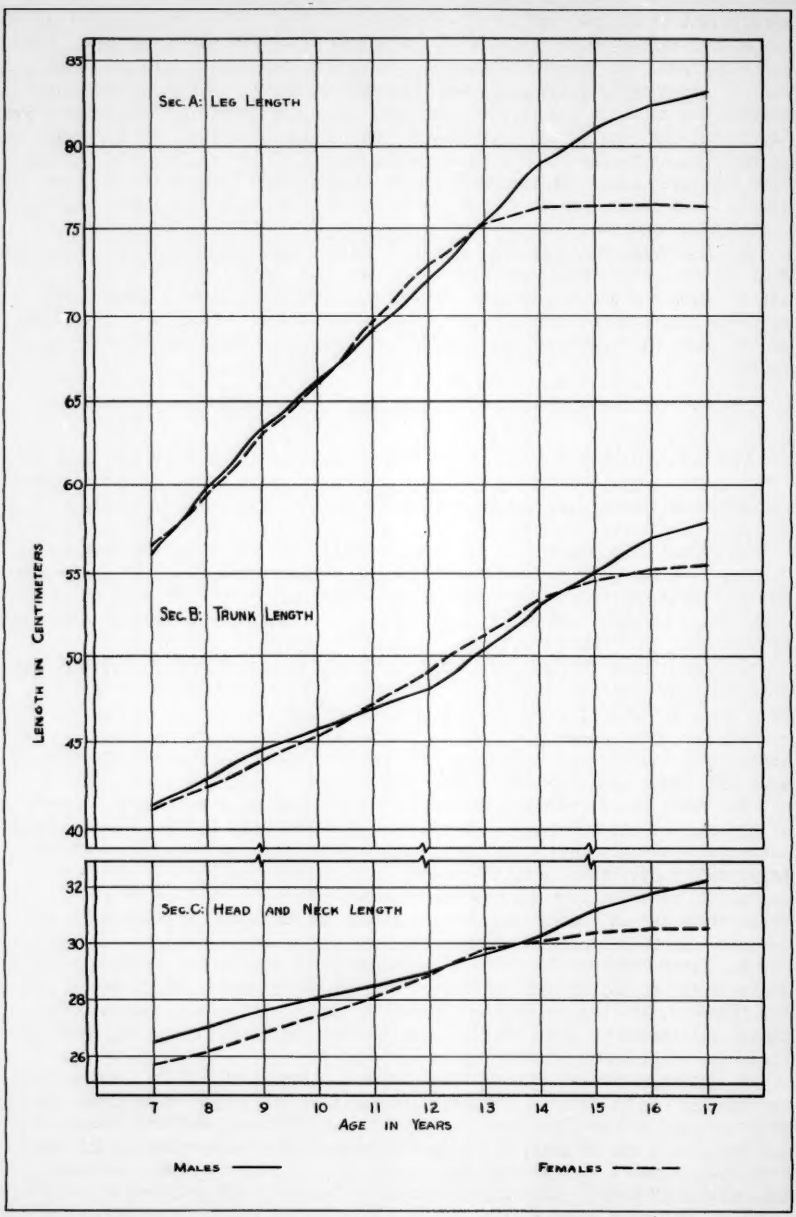


Fig. 1. Curves for length of head and neck (vertex-supersternale), length of trunk (supersternale-rump), and length of lower extremities (rump-sole). Drawn to the series of means for each sex given in Tables 1, 2, and 3, respectively.

coefficient at 5.8 per cent.

8. Of the cases at each age studied 50 per cent fall within a zone of less than one inch. For the years 7 to 10, inclusive, the zone of the middle 50 per cent is approximately 1.6 cms. For the years 12 to 16, inclusive, this zone is roughly 2.2 cms. In the case of each sex, the upper limit of the zone at 7 years (26.6 cms. for females and 27.3 cms. for males) is about equal to the lower limit of the zone at 10 years (26.7 cms. for females and 27.3 cms. for males). Likewise the upper limits of the zones at 10 years are about equal to the lower limits at 13 years, and the upper limits at 13 years about equal to the lower limits at 17 years.

9. The total range at each age from 7 to 11 years approximates two and one-half inches. At each age from 13 to 17 years the total range lies in the vicinity of three and one-half inches. In general, the successive distributions overlap each other to the extent of about 80 to 85 per cent. The upper 5 per cent of the cases at 7 years of age overlap the lower 5 per cent of the cases at 17 years.

## TRUNK LENGTH

The data on trunk (supersternale-rump) length parallel those for head and neck length. Both dimensions were obtained on the same sample of subjects and at like ages throughout. Consequently, the number of values is the same - 1,344 for males and 1,391 for females.

The total of 2,735 values for trunk length, like those for head and neck length, were grouped into twenty-two frequency distributions - eleven for each sex representing consecutive annual-age-interval midpoints from 7 to 17 years, inclusive. Results from statistical reduction of these distributions are given in Table 2. This table yields the following findings:

1. Mean trunk length, both sexes combined, is approximately 41.1 cms., or 16.2 in., at 7 years of age; 50.9 cms., or 20.0 in., at 13 years of age; and 56.8 cms., or 22.4 in., at 17 years of age.

2. For males, mean trunk length is 41.2 cms. at 7 years, 50.3 cms. at 13 years, and 58.1 cms. at 17 years. For females, means at corresponding ages are 41.0 cms., 51.4 cms., and 55.5 cms.

3. Means at 13 years exceed means at 7 years by 9.1 cms., or 22.1 per cent, in the case of males and by 10.4 cms., or 25.4 per cent, in the case of females. Means at 17 years exceed means at 7 years by 16.9 cms., or 41.0 per cent for males and by 14.5 cms., or 35.4 per cent, for females.

4. In relation to mean size at 17 years, the means at 7 and 13 years, respectively, are equivalent to 71 per cent and 87 per cent for males and to 74 per cent and 93 per cent for females.

5. Trunk length means for males exceed those for females and from 7 through 10 years and at 15, 16, and 17 years. The amount of excess is 0.5 cms. at 8, 10, and 15 years, 1.9 cms. at 16 years, and 2.6 cms. at 17 years. Female means exceed male means by slightly more than one centimeter at 12 and 13 years. (See Figure 1, Section B).

6. The standard deviations fall within the limits of 1.7 cms. and 2.7 cms. for females and 2.2 cms. and 3.6 cms. for males. The female values show a gradual rise from 1.7 cms. at 8 years to 2.7 cms. at 13 years and then decline to 2.2 cms. at 16 and 17 years. The male values stand at approximately 2.2 cms. from 7 to 11 years then show a rise to 3.6 cms. at 14 years and a decline to 2.6 cms. at 17 years. Identical figures for each sex are obtained at 12 years and most divergent figures (2.5 cms. for females and 3.6 cms. for males) at 14 years.

7. Coefficients of variation fluctuate from 3.9 per cent to 5.3 per cent

TABLE 2

TRUNK LENGTH (CENTIMETERS): MEAN, STANDARD DEVIATION, COEFFICIENT OF VARIATION, LIMITS OF INTERQUARTILE RANGE, AND RANGE AT ANNUAL AGE INTERVALS FROM SEVEN TO SEVENTEEN YEARS

| Mean Age, Years | Cases | Mean | Standard Deviation | Coefficient of Variation | 25th Percentile | 75th Percentile | Range |
|---|---|---|---|---|---|---|---|
| | | | | Males | | | |
| 7 | 113 | 41.2 | 2.2 | 5.4 | 39.7 | 42.7 | 36.3 to 47.7 |
| 8 | 107 | 43.0 | 2.3 | 5.4 | 41.3 | 44.7 | 38.2 to 48.3 |
| 9 | 103 | 44.5 | 2.2 | 5.0 | 43.1 | 45.8 | 39.7 to 50.4 |
| 10 | 105 | 45.8 | 2.2 | 4.8 | 44.2 | 47.2 | 41.8 to 51.4 |
| 11 | 96 | 47.0 | 2.3 | 4.8 | 45.3 | 48.7 | 41.9 to 51.9 |
| 12 | 90 | 48.1 | 2.5 | 5.2 | 46.3 | 49.7 | 43.2 to 54.7 |
| 13 | 103 | 50.3 | 3.2 | 6.4 | 48.0 | 52.5 | 43.0 to 58.2 |
| 14 | 138 | 52.9 | 3.6 | 6.7 | 50.6 | 55.5 | 44.2 to 60.1 |
| 15 | 163 | 55.0 | 3.3 | 6.0 | 52.7 | 57.1 | 47.3 to 62.1 |
| 16 | 172 | 57.1 | 2.9 | 5.0 | 55.1 | 59.1 | 49.2 to 64.8 |
| 17 | 154 | 58.1 | 2.6 | 4.6 | 56.5 | 59.8 | 51.5 to 65.3 |
| | | | | Females | | | |
| 7 | 107 | 41.0 | 1.8 | 4.4 | 39.6 | 42.3 | 35.6 to 45.4 |
| 8 | 100 | 42.5 | 1.7 | 4.1 | 41.2 | 43.7 | 38.9 to 47.9 |
| 9 | 95 | 43.9 | 1.9 | 4.4 | 42.7 | 44.9 | 38.6 to 48.6 |
| 10 | 116 | 45.3 | 2.0 | 4.5 | 44.1 | 46.6 | 40.7 to 51.7 |
| 11 | 113 | 47.1 | 2.4 | 5.1 | 45.7 | 48.5 | 40.8 to 53.0 |
| 12 | 120 | 49.3 | 2.5 | 5.0 | 47.5 | 50.8 | 43.7 to 55.9 |
| 13 | 114 | 51.4 | 2.7 | 5.3 | 49.7 | 53.4 | 44.3 to 58.5 |
| 14 | 154 | 53.4 | 2.5 | 4.7 | 51.6 | 55.1 | 46.1 to 59.0 |
| 15 | 165 | 54.5 | 2.4 | 4.4 | 53.0 | 56.1 | 48.4 to 60.5 |
| 16 | 155 | 55.2 | 2.2 | 4.0 | 53.7 | 56.8 | 49.6 to 60.4 |
| 17 | 152 | 55.5 | 2.2 | 3.9 | 54.1 | 57.2 | 49.7 to 60.2 |

for females and from 4.6 per cent to 6.7 per cent for males. The male coefficients decrease from 5.4 per cent at 7 years to 4.8 per cent at 11 years, rise to 6.7 per cent at 14 years, and decrease to 4.6 per cent at 17 years. The female coefficients stand at about 4.4 per cent between 7 and 10 years, increase to 5.3 per cent at 13 years, and decrease to 3.9 per cent at 17 years. As for absolute variability, maximum divergence of the sexes occurs at 14 years.

8. Of the cases at each age studied 50 per cent fall within a zone of one and one-half inches for females and two inches for males. For the years 7 to 10, inclusive, the zone of the middle 50 per cent is approximately 2.5 cms. for females and 3.0 cms. for males. The female values rise from 2.8 cms. at 11 years to 3.7 cms. at 13 years and then decline to 3.1 cms. at 15, 16, and 17 years. The male values rise from 3.4 cms. at 11 years to 4.9 cms. at 14 years and then decline to 3.3 cms. at 17 years. In the case of each sex, the upper limit of the zone at 7 years is about equal to the lower limit of the zone at 9 years. Likewise, the upper limits of the zones at 9, 11, and 13 years are roughly equal to the lower limits at 11, 13, and 15 years, respectively.

9. For females, the total range approximates four inches at 7, 9, and 17 years; four and three-fourth inches at 11 and 15 years; and five and one-half inches at 13 years. For males, the total range is four to four and one-half inches between 7 and 12 years, six and one-fourth inches at 14 years, and five and one-half inches at 17 years. In general, the successive distributions from 7 years to around 14 years for females and 16 years for males overlap each other

to the extent of about 70 per cent. There is no overlapping of the distributions at 8 and 16 years, i.e., every case studied at 16 years had a trunk length exceeding nineteen and one-fourth inches and no case studied at 8 years gave a trunk length reading in excess of nineteen inches.

## LEG LENGTH

The data are strictly comparable with those for head and neck length and trunk length. The subjects and times of examination were identical throughout.

For males, the 1,344 leg length values were distributed among eleven one-year age divisions. The 1,391 leg length values for females were similarly distributed. Midpoints of the age groupings for each sex fell at successive annual intervals from 7 to 17 years, inclusive.

Table 3 consists of eight columns of figures considered to give a reasonably comprehensive tabular description of the absolute magnitude of leg length (derived as stature minus stem length) between 7 and 17 years of age. Selected findings from this table, supplemented by comparative material on head and neck length and trunk length, are:

1. Mean leg length, both sexes combined, is approximately 56.2 cms., or 22.1 in., at 7 years of age; 75.3 cms., or 29.6 in., at 13 years of age; and 79.9 cms., or 31.5 in., at 17 years of age. At 7 years leg length stands roughly at 56 cms. (22 in.), trunk length at 41 cms. (16 in.), and head and neck length at 26 cms. (10 in.).

2. For males, mean leg length is 56.1 cms. at 7 years, 75.5 cms. at 13 years, and 83.2 cms. at 17 years. For females, means at corresponding ages are 56.4 cms., 75.1 cms., and 76.5 cms. For males age 17 years leg length approximates 83 cms. (33 in.), trunk length 58 cms. (23 in.), and head and neck length 32 cms. (13 in.). For females at the same age corresponding values are 76 cms. (30 in.) leg length, 55 cms. (22 in.) trunk length, and 30 cms. (12 in.) head and neck length.

3. Means at 13 years exceed means at 7 years by 19.4 cms., or 34.6 per cent, in the case of males and by 18.7 cms., or 33.2 per cent, in the case of females. Means at 17 years exceed means at 7 years by 27.1 cms., or 48.3 per cent for males and by 20.1 cms., or 35.6 per cent for females. The percentage increase at 17 years on size at 7 years is roughly 48 leg length, 41 trunk length, and 22 head and neck length for males, and 36 leg length, 35 trunk length, and 19 head and neck length for females.

4. In relation to mean size at 17 years, the means at 7 years for leg length, trunk length, and head and neck length, respectively, are equivalent to 67 per cent, 71 per cent, and 82 per cent in the case of males, and 74 per cent, 74 per cent, and 84 per cent in the case of females. Means at 13 years in percentage of means at 17 years are, for males, 91 leg length, 87 trunk length, and 92 head and neck length, for females, 98 leg length, 93 trunk length, and 97 head and neck length.

5. Leg length means for males and females are practically equal during the age period from 7 through 10 years. At 11 years females exceed males by 0.7 cms. and at 12 years by 0.9 cms. Males exceed females by 2.7 cms. at 14 years, 4.4 cms. at 15 years, 5.9 cms. at 16 years, and 6.7 cms. at 17 years. (See Figure 1, Section A). At 7 years of age there is no appreciable difference between males and females in mean leg length, mean trunk length, or mean head and neck length. At 17 years of age males exceed females by 1.7 cms. in mean head and neck length, 2.6 cms. in mean trunk length, and 6.7 cms. in mean leg length.

6. The standard deviations for leg length fall within the limits of 3.0 cms. and 3.9 cms. for females and 2.9 cms. and 4.7 cms. for males. The female values stand at 3.0 cms. or 3.1 cms. at 7, 8, and 9 years of age and fluctuate between 3.7 cms. and 3.9 cms. during the period from 11 to 17 years. The male

TABLE 3

LEG LENGTH (CENTIMETERS): MEAN, STANDARD DEVIATION, COEFFICIENT OF VARIATION, LIMITS OF INTERQUARTILE RANGE, AND RANGE AT ANNUAL AGE INTERVALS FROM SEVEN TO SEVENTEEN YEARS

| Mean Age, Years | Cases | Mean | Standard Deviation | Coefficient of Variation | 25th Percentile | 75th Percentile | Range |
|---|---|---|---|---|---|---|---|
| | | | Males | | | | |
| 7 | 113 | 56.1 | 2.9 | 5.2 | 54.2 | 58.2 | 49.0 to 62.8 |
| 8 | 107 | 59.9 | 3.0 | 5.0 | 57.8 | 62.2 | 52.8 to 66.9 |
| 9 | 103 | 63.4 | 3.4 | 5.3 | 61.2 | 65.7 | 55.0 to 70.1 |
| 10 | 105 | 66.2 | 3.5 | 5.3 | 63.6 | 68.4 | 58.5 to 74.8 |
| 11 | 96 | 69.0 | 3.6 | 5.2 | 66.2 | 70.6 | 61.4 to 77.6 |
| 12 | 90 | 72.0 | 3.9 | 5.4 | 68.9 | 74.6 | 63.7 to 81.2 |
| 13 | 103 | 75.5 | 4.2 | 5.5 | 72.7 | 78.6 | 65.6 to 84.7 |
| 14 | 138 | 79.2 | 4.5 | 5.7 | 76.3 | 82.3 | 67.6 to 91.8 |
| 15 | 163 | 80.9 | 4.7 | 5.8 | 78.3 | 83.8 | 68.1 to 92.8 |
| 16 | 172 | 82.5 | 4.3 | 5.2 | 79.9 | 85.3 | 69.2 to 94.3 |
| 17 | 154 | 83.2 | 4.2 | 5.1 | 80.6 | 86.0 | 70.6 to 94.8 |
| | | | Females | | | | |
| 7 | 107 | 56.4 | 3.0 | 5.3 | 54.0 | 58.5 | 50.3 to 63.4 |
| 8 | 100 | 59.5 | 3.1 | 5.2 | 57.3 | 61.9 | 51.6 to 66.1 |
| 9 | 95 | 63.0 | 3.0 | 4.8 | 60.8 | 65.3 | 56.5 to 69.3 |
| 10 | 116 | 66.1 | 3.4 | 5.1 | 63.9 | 68.6 | 57.7 to 74.2 |
| 11 | 113 | 69.7 | 3.8 | 5.4 | 67.0 | 72.1 | 60.8 to 78.3 |
| 12 | 120 | 72.9 | 3.7 | 5.1 | 70.3 | 75.3 | 62.9 to 82.0 |
| 13 | 114 | 75.1 | 3.9 | 5.2 | 72.7 | 77.6 | 64.7 to 83.5 |
| 14 | 154 | 76.5 | 3.9 | 5.1 | 73.6 | 79.2 | 66.9 to 86.1 |
| 15 | 165 | 76.5 | 3.9 | 5.1 | 73.7 | 79.2 | 67.6 to 86.4 |
| 16 | 155 | 76.6 | 3.7 | 4.9 | 74.0 | 79.1 | 67.4 to 86.6 |
| 17 | 152 | 76.5 | 3.9 | 5.1 | 73.7 | 78.9 | 67.7 to 86.1 |

values show a gradual rise from 2.9 cms. at 7 years to 4.7 cms. at 15 years, followed by a decline to 4.2 cms. at 17 years. In general, absolute variation is least for head and neck length, intermediate for trunk length, and greatest for leg length.

7. Coefficients of variation fluctuate between 4.8 per cent and 5.4 per cent for females and between 5.0 per cent and 5.8 per cent for males. During the interval 12 to 17 years, the male coefficients rise from 5.4 at 12 years to 5.8 at 15 years and decline to 5.1 at 17 years, the female coefficients remain near 5.1 per cent at each of the six ages. Composite figures for relative variability (derived as the mean of the series of eleven coefficients of variation for each dimension on each sex) are 4.5 per cent for trunk length of females, 5.1 per cent for leg length of females and for head and neck length of males and females, 5.3 per cent for leg length of males, and 5.4 per cent for trunk length of males.

8. At each age studied 50 per cent of the cases for leg length fall within a zone of one and one-half to two and one-half inches. For the years 7 to 10, inclusive, the zone of the middle 50 per cent is approximately 4.5 cms. for each sex. For the years 12 to 17, inclusive, this zone is roughly 5.2 cms. for females and 5.6 cms. for males. In general, the middle 50 per cent fall within a zone of less than one inch for head and neck length, around one and one-half inch for trunk length, and about two inches for leg length.

9. For both sexes, the total range in leg length increases from slightly

more than five inches at 7 years to approximately seven and one-half inches at 13 years. For the years 14 to 17, inclusive, the total range for males is roughly nine and one-half inches while that for females remains at seven and one-half inches. There is no overlapping of the leg length distributions at 7 and 12 years for males or at 7 and 13 years for females. Likewise there is no overlapping at 9 and 17 years for males, though the female distributions for these two ages overlap to the extent of about 8 per cent.

## COMPONENTS OF STATURE

Stature may be defined as a composite dimension consisting of length of head and neck, length of trunk, and length of lower extremities. It follows, then, that by expressing the means at a given age for each of these three components in percentages of mean stature at the same age, one may obtain representative figures for the relative amount each contributes to stature. Moreover, by following this procedure at the various ages under study, mean trends of change for each component in percentage of stature may be examined.

Table 4 gives the percentage of mean stature of males and females contributed by head and neck length, trunk length, and leg length at each age from 7 to 17 years. Trends drawn to the six series of percentages from this table are shown in Figure 2. Findings accruing from both the tabular and graphic material are:

1. For males, head and neck length decreases from 21.4 per cent of stature at 7 years to 18.6 per cent of stature at 15 years and remains constant at 18.6 per cent between 15 and 17 years. For females, there is a similar trend - the decline being from 20.9 per cent at 7 years to 18.8 per cent at 14 years and the constant figure being 18.8 per cent for the years 14 to 17. Head and neck length in percentage of stature is slightly higher for males than for females between 7 and 12 years and for females than for males between 14 and 17 years.

2. For both males and females, trunk length in percentage of stature decreases from 33.3 at 7 years to 32.5 at 11 years. Between 12 and 17 years, trunk length in percentage of stature increases from 32.3 to 33.5 for males and from 32.6 to 34.1 for females. Trunk length is exactly one-third of stature at 7 years for males and females and at 16 years for males. For females at 16 years it is 34 per cent.

3. Leg length of males increases from 45.3 per cent of stature at 7 years to 48.7 per cent at 14 years. Between 14 and 17 years there is a decline from 48.7 per cent to 47.9 per cent. For females, leg length in percentage of stature shows a rise from 45.8 at 7 years to 48.3 at 12 years which is followed by a gradual decline to 47.1 at 17 years.

4. In relation to stature at 7 years of age, leg length is greater for females than for males, head and neck length is greater for males than for females, and trunk length is identical for both sexes. In relation to stature at 17 years, leg length is greater for males than for females, trunk length is greater for females than males, and head and neck length slightly greater for females than for males. Identical percentages for the two sexes are obtained at 7, 10, and 11 years in the case of trunk length, 12 years for leg length, and 13 years for head and neck length.

Additional perspective on changes with age among the components of stature may be obtained by supplementing the trends from 7 to 17 years with material indicative of the major changes during prenatal life and the early postnatal years. It will suffice to review findings at four selected ages (2, 8, and 19 weeks prenatal age and 12 months postnatal age) and to align these with findings from the present study at 8, 13, and 17 years.

Two weeks prenatal age: In a discussion of research findings on embryonic

TABLE 4

MEAN HEAD AND NECK LENGTH, TRUNK LENGTH, AND LEG LENGTH IN PERCENTAGE OF MEAN STATURE

| Mean Age, Years | Head and Neck Length | Trunk Length | Leg Length |
|---|---|---|---|
| | Males | | |
| 7 | 21.4 | 33.3 | 45.3 |
| 8 | 20.8 | 33.1 | 46.1 |
| 9 | 20.4 | 32.8 | 46.8 |
| 10 | 20.0 | 32.7 | 47.3 |
| 11 | 19.7 | 32.5 | 47.8 |
| 12 | 19.4 | 32.3 | 48.3 |
| 13 | 19.0 | 32.4 | 48.6 |
| 14 | 18.7 | 32.6 | 48.7 |
| 15 | 18.6 | 32.9 | 48.5 |
| 16 | 18.6 | 33.3 | 48.1 |
| 17 | 18.6 | 33.5 | 47.9 |
| | Females | | |
| 7 | 20.9 | 33.3 | 45.8 |
| 8 | 20.4 | 33.2 | 46.4 |
| 9 | 20.0 | 32.9 | 47.1 |
| 10 | 19.7 | 32.7 | 47.6 |
| 11 | 19.4 | 32.5 | 48.1 |
| 12 | 19.1 | 32.6 | 48.3 |
| 13 | 19.0 | 32.9 | 48.1 |
| 14 | 18.8 | 33.4 | 47.8 |
| 15 | 18.8 | 33.8 | 47.4 |
| 16 | 18.8 | 34.0 | 47.2 |
| 17 | 18.8 | 34.1 | 47.1 |

growth published in 1928, Jackson (2) pointed out that at the end of the second week following fertilization the embryonic disk is less than one millimeter in length and consists largely of head and neck region. Particularly pertinent is his statement: "...the head region is relatively enormous, occupying nearly half the total area. The neck or cervical region is about half as large as the head, and the other segments of the trunk decrease progressively in size toward the tail region." (2, p. 114). This statement appears conservatively interpreted as implying that at the age of two weeks stature (in so far as the term stature can be applied to the organism at this age) consists of roughly 65 per cent head and neck length and 35 per cent trunk length.

Eight weeks prenatal age: Schultz (5), in 1926, reported a study on a small series of fetuses at nine weeks menstrual age, i.e., almost eight weeks fertilization age. He found stem (vertex-rump) length, taken with the stem of each specimen extended on a board, to yield an average of 31 mm. Stature, measured as vertex-pubes plus thigh length plus knee-sole, gave an average of 36 mm., or 115.8 per cent of stem length. Derived as stature minus stem length, leg length was thus found to approximate 5 mm. Other proportionate values reported by Schultz permit one to obtain estimates of 17.5 mm. for head and neck length (vertex-supersternale) and 13.5 mm. for trunk length (supersternale-rump). On the basis of these figures, stature at eight weeks intra-uterine age may be taken to consist of 49 per cent head and neck length, 37 per cent trunk length, and 14 per cent leg length.

Nineteen weeks prenatal age: Scammon and Calkins (4) obtained an extensive series of measurements on fetuses at all ages from 3 to 10 lunar months. Their tables, published in 1929, include means for vertex-heel length, vertex-rump length, and vertex-supersternale length on fetuses at 20 weeks menstrual age

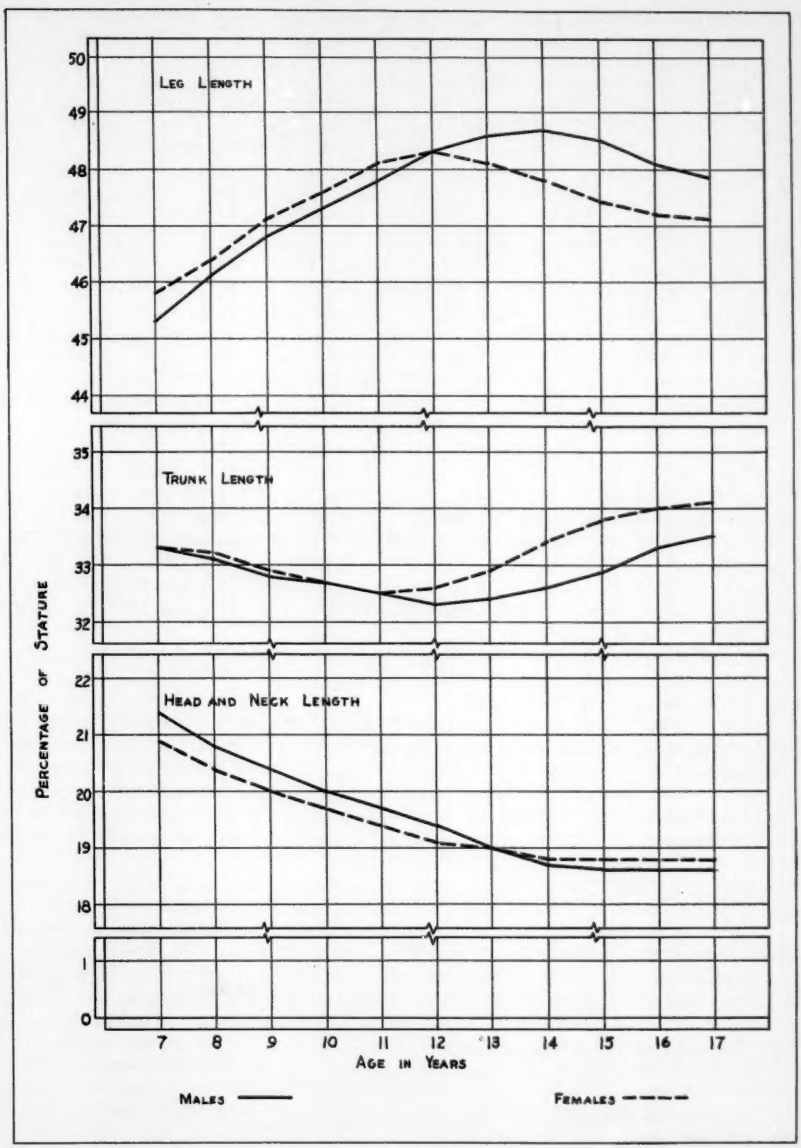


Fig. 2. Trends for the age period from seven to seventeen years showing the proportion of mean stature at each age contributed by mean head and neck (vertex-supersternale) length, mean trunk (supersternale-rump) length, and mean leg (rump-sole) length.

(nearly 19 weeks fertilization age). The mean at this age for vertex-supersternale, or head and neck length, is 72.4 mm. Means for trunk length (vertex-rump minus vertex-supersternale) and for leg length (vertex-heel minus vertex-rump) are 83.0 mm. and 72.5 mm., respectively. Cast in terms of proportionate parts of stature, these means give percentages of 31.8 each for leg length and for head and neck length, and 36.4 for trunk length. It will be noted that these percentages represent the midpoint of the typical duration of the prenatal period.

One year postnatal age: Representative values at this age may be derived from studies published in 1938 by Gesell and Thompson (1) and by Meredith and Knott (3). As one item of a comprehensive investigation covering the first year following birth, Gesell and Thompson report head and neck length means of 18.9 cms. for 19 males and 18.5 cms. for 24 females. Converted to percentages of stature these values become 25.0 for males and 25.1 for females. Meredith and Knott, in a study of stem length and leg (stature minus stem) length covering the first six years of postnatal life, give leg length means at one year of 27.7 cms. for 152 males and of 27.2 cms. for 119 females. Converted to percentages of stature these values become 36.3 and 36.5, respectively. In general, then, at one postnatal year of age head and neck length approximates 25 per cent of stature, trunk length 39 per cent, and leg length the remaining 36 per cent.

A convenient medium for diagrammatically summarizing the findings of the preceding four paragraphs, and selected original findings on changes with age among the components of stature, is afforded by the histogram. Accordingly, Figure 3 employs this medium to portray the relative amounts of head and neck length, trunk length, and leg length which combine to give stature at seven different ages. The values at the three prenatal ages were obtained without regard to sex. At the four postnatal ages the values represent figures for males. From the standpoint of the anatomic landmarks involved, the three segments of stature are strictly comparable throughout.

## INTERRELATION OF COMPONENTS OF STATURE

The interrelations of head and neck length, trunk length, and leg length were studied in two ways. Analysis was restricted in each instance to the data for males.

The first approach was that of calculating the Pearson product-moment correlation coefficient at each age for head and neck length with trunk length, trunk length with leg length, and head and neck length with leg length. The following tabulation presents the coefficients obtained.

Pearson Product-Moment Correlation Coefficients for Males

| Age | Head and Neck Length With Trunk Length | Trunk Length With Leg Length | Head and Neck Length With Leg Length |
|---|---|---|---|
| 7 | .23 | .50 | .51 |
| 8 | .21 | .53 | .38 |
| 9 | .34 | .58 | .46 |
| 10 | .33 | .47 | .44 |
| 11 | .30 | .45 | .44 |
| 12 | .26 | .54 | .34 |
| 13 | .36 | .61 | .47 |
| 14 | .44 | .61 | .49 |
| 15 | .43 | .57 | .46 |
| 16 | .24 | .38 | .30 |
| 17 | .24 | .34 | .36 |

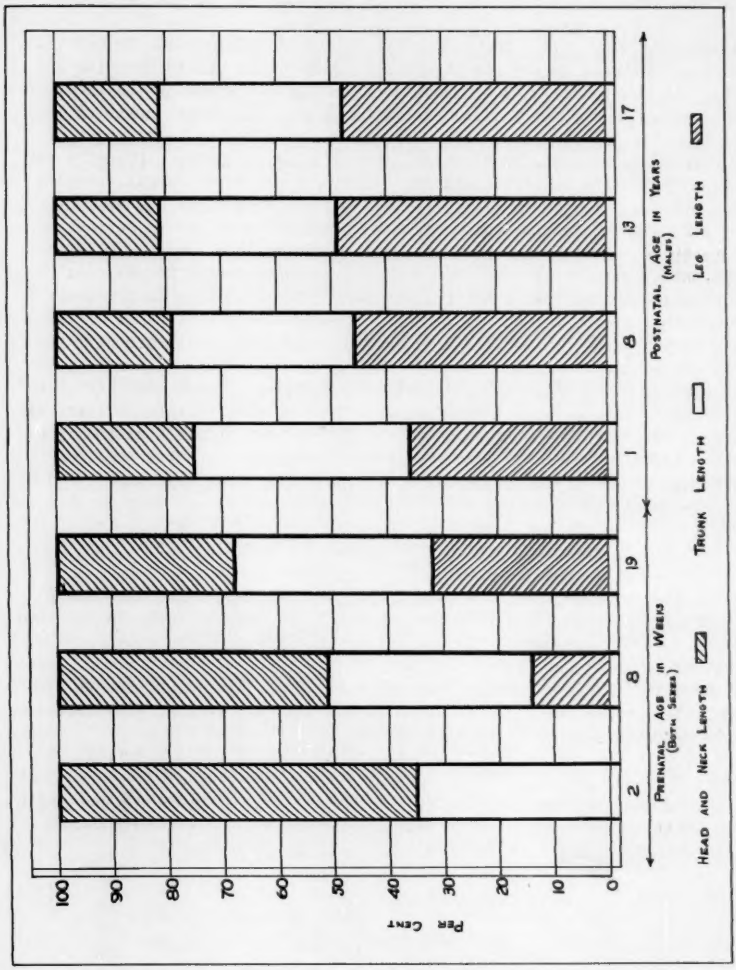


Fig. 3. Bar diagram showing the percentage contributed to stature by each of its three major components at seven selected ages between fertilization and adulthood.

Findings from this tabulation are:

1. For head and neck length with trunk length, the coefficients fluctuate between .21 and .44. The mean value of the series is .31.

2. For trunk length with leg length, the coefficients range from .34 to .61 and give a mean of .51.

3. For head and neck length with leg length, the coefficients vary between .30 and .51, the mean value for the series being .42.

4. In general, the coefficients are greatest for trunk length with leg length, intermediate for head and neck length with leg length, and least for head and neck length with trunk length. From the magnitude of the coefficients it follows that while there is some degree of positive relation between each pair of stature components, in no instance is the relation "high."

5. There is a tendency for the relation between each pair of stature components to be slightly greater at 13 to 15 years than before or following these ages.

The second approach to interrelationships consisted of obtaining the percentile rankings of selected cases in head and neck length, trunk length, and leg length. Three ages were chosen for study - 9, 13, and 17 years. At these ages percentile tables were constructed for each of the three dimensions. The tables at 9 and 13 years were each based on 103 cases and those at 17 years on 154 cases.

In order to minimize any errors of measurement that might spuriously influence material on "percentile position of the individual in the group for a given dimension at a given age," the cases to be presented were required to meet certain specifications. These specifications necessitated that for a case to be eligible for presentation its file record must 1) carry at least two other series of measurement values adjacent to the series proposed for use, 2) show that the three series of values were obtained within an age period not exceeding two years, and 3) give nonerratic values for stature, stem length, and trunk length from the three examinations. The advisability of following this rigorous procedure was considered indicated both by the nature of the data and by the nature of the problem. Since the data for head and neck length and for leg length were obtained as derived measurements, it was imperative to use particular caution in the determination of individual types of interrelationship. Moreover, the problem being that of presenting divergent stature configurations for selected individual cases, it was desirable to employ methods that would yield assurance that the validity of the comparisons made was reasonably unequivocal.

No attempt will be made to enumerate all types of interrelationship found. The objective is that of selecting and arranging a series of cases which are illustrative of the variety of contrasting combinations of head and neck length, trunk length, and leg length obtained. The manner of presenting the material will be to state a general interrelation of the three stature components and then cite specific cases showing this interrelation.

1. Long head and neck, long trunk, long legs. The percentile positions of Case 7100, aged 9 years, are 96 for head and neck length, 99 for trunk length, and 96 for leg length. Listed in the same order, the percentile rankings at 13 years are 99, 91, and 90 for Case 5641 and 91, 91, and 93 for Case 40. Those of Case 7274 at 17 years are 98, 90, and 95.

2. Short head and neck, short trunk, short legs. Case 9041, aged 9 years, yields percentile rankings of 2 for head and neck length, 4 for trunk length, and 1 for leg length. Corresponding percentile placements are 11, 11, and 11 for Case 8968 at 9 years; 7, 3, and 5 for Case 96 at 13 years; 6, 1, and 4 for Case 3749 at 17 years; and 9, 4, and 6 for Case 2863 at 17 years.

3. Long head and neck, average trunk, long legs. At 9 years of age, Case

6826 gives percentile rankings of 98 for head and neck length, 43 for trunk length, and 82 for leg length. Comparable percentile positions are 97, 59, and 89 for Case 43 at 13 years and 83, 44, and 96 for Case 4080 at 17 years. A similar type of interrelationship is shown by Case 4020 at 9 years (70, 33, 85) and by Case 4320 at 17 years (62, 17, 91).

4. Short head and neck, average trunk, short legs. Case 3280, aged 9 years, registers percentile positions of 1, 45, and 4 for head and neck length, trunk length, and leg length, respectively. Listed in the same order, the percentile placements of Case 9667 at 9 years are 7, 62, and 19; of Case 5184 at 13 years are 1, 53, and 8; of Case 6022 at 17 years are 5, 64, and 23; and of Case 5833 at 17 years are 26, 85, and 4.

5. Long head and neck, average trunk, average legs. The percentile rankings of Case 90, aged 9 years, are 95 for head and neck length, 32 for trunk length, and 34 for leg length. Corresponding percentiles are 93, 37, and 50 for Case 1741 at 13 years and 98, 54, and 65 for Case 8383 at 17 years.

6. Short head and neck, average trunk, average legs. Case 8400, aged 9 years, shows percentile positions of 16 for head and neck length, 45 for trunk length, and 62 for leg length. Comparable percentiles for Case 500 at 13 years are 10, 52, and 51. Those for Case 1570 at 17 years are 8, 44, and 33.

7. Average head and neck, short trunk, average legs. At 9 years of age, Case 6544 gives percentile rankings of 44 for head and neck length, 3 for trunk length, and 32 for leg length. Listed in the same order, the percentiles for Case 4240 at 13 years are 47, 5, and 60. Those for Cases 6896 and 9881 at 17 years are 57, 7, 63 and 41, 4, 36. A similar type of interrelationship is shown by Case 1685 at 9 years (65, 19, 92), by Case 4801 at 9 years (82, 10, 49), and by Case 6546 at 17 years (45, 8, 70).

8. Average head and neck, average trunk, short legs. Case 8519, aged 9 years, registers percentile placements of 44 for head and neck length, 55 for trunk length, and 6 for leg length. Comparable percentile figures are 51, 65, and 9 for Case 740 at 13 years and 62, 38, and 3 for Case 9668 at 17 years. Case 1320 at 9 years shows moderately long head and neck length with fairly short trunk and leg lengths - the percentiles are 60, 19, and 17. Moderately long head and neck length and trunk length with short leg length is shown by Case 920 at 13 years (75, 77, 19) and by Case 1118 at 17 years (72, 75, 8).

9. Short head and neck, average trunk, long legs. The percentile positions of Case 3558, aged 9 years, are 24 for head and neck length, 60 for trunk length, and 99 for leg length. Parallel series of percentiles are shown by Case 6400 at 9 years (16, 44, 82), by Case 201 at 13 years (42, 87, 97), by Case 6600 at 17 years (40, 63, 87), and by Case 3768 at 17 years (2, 20, 59).

10. Long head and neck, average trunk, short legs. At 9 years of age, Case 7588 yields percentile rankings of 85 for head and neck length, 50 for trunk length, and 30 for leg length. Generally comparable series of percentiles are given by Case 763 at 9 years (94, 82, 38), by Case 3036 at 13 years (94, 83, 55), by Case 5832 at 13 years (47, 24, 7), by Case 401 at 17 years (92, 70, 29) and by Case 9668 at 17 years (62, 38, 3).

11. Average head and neck, long trunk, average legs. Case 4046, aged 9 years, registers percentile placements of 68 for head and neck length, 97 for trunk length, and 54 for leg length. Listed in the same order, percentiles for Case 5089 at 17 years are 69, 98, and 39. Case 2516 at 13 years shows short head and neck, moderately long trunk, and moderately short legs - the percentile figures are 5, 65, and 30, respectively. Case 1355 at 17 years illustrates moderately long trunk (67) with moderately short head and neck (33) and legs (36).

SUMMARY

The data consist of approximately 2,700 values each for length of head and neck, length of trunk, and length of lower extremities. These data were obtained on roughly 740 Iowa City children of northwest European descent. They are distributed over the age period from six and one-half years to seventeen and one-half years.

Central tendency and variability findings, specific for sex and annual age groupings, are presented separately for head and neck length, trunk length, and length of lower extremities. Graphic comparison is made of the mean trends for the two sexes in each dimension.

The series of means from seven to seventeen years for each of the three dimensions are next expressed as percentages of mean stature. Curves are given to show the changes in proportion of mean stature contributed by each dimension at successive ages.

Finally, the interrelation of the three dimensions is treated. Coefficients of correlation are obtained for head and neck length with trunk length, trunk length with length of lower extremities, and head and neck length with lower extremities. Types of interrelationship for specific individuals are illustrated by giving, for each of fifty cases selected at three ages, percentile rankings in the three dimensions.

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# THE EFFECT OF INCLUDING INCOMPLETE SERIES IN THE STATISTICAL ANALYSIS OF LONGITUDINAL MEASUREMENTS OF CHILDREN'S DENTAL ARCHES[1]

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Shuttleworth[2] points out that many investigators lose much of the value of the longitudinal data which have been obtained on the same children over a period of years because they use the statistical techniques that have been developed for the analysis of cross-section data. It is also possible that treatment without regard to the nature of the data may lead to error, especially if sampling restrictions are neglected.

Recently in working over measurements on the dental arches of children obtained in a longitudinal study, an interesting demonstration of the effect of the selection of cases upon results came to light. In this study plaster casts were made of children's teeth and arches at yearly intervals. The taking of these casts was begun when the children were in the nursery school of the Institute of Child Welfare at the University of Minnesota. Later, as the children moved on into grammar and high school, casts were obtained at yearly intervals. For various reasons, illness, moving from the city, lack of cooperation, etc., there were many casualties and losses. Some series covered spans of several years and were then dropped, while others continued from 2 to 16 years. Although an attempt was always made to secure the casts as nearly as possible on the child's birth date, various practical considerations, such as vacations, illness, etc., made this impossible. In the first analysis of the data, all the cases within any year level were grouped together, the means and standard deviations obtained, and the curves of the separate measurements plotted with age, entering the means at the half-year points. There was so much irregularity in the curves obtained that it was obvious they did not reflect the true development of the dental arches.

In Table 1 a distribution of the total number of casts available at each age level by age and sex is presented. In this table it is clear that a much larger number of cases is available in the earlier than the later years. From these cases the records of 15 boys and 13 girls on whom measures had been obtained

TABLE 1

DISTRIBUTION OF ALL CASTS BY AGE AND SEX

| | Whole Group | | |
|---|---|---|---|
| Age | Boys | Girls | Total |
| 3-6 | 39 | 25 | 64 |
| 4-6 | 43 | 32 | 75 |
| 5-6 | 51 | 39 | 90 |
| 6-6 | 26 | 26 | 52 |
| 7-6 | 21 | 15 | 36 |
| 8-6 | 23 | 17 | 40 |
| 9-6 | 22 | 19 | 41 |
| 10-6 | 25 | 14 | 39 |
| 11-6 | 14 | 15 | 29 |
| 12-6 | 14 | 8 | 22 |
| 13-6 | 12 | 7 | 19 |

[1]*From the Institute of Child Welfare, University of Minnesota.*

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[2]*Shuttleworth, Frank K. Sexual maturation and the physical growth of girls age six to nineteen. Monographs of the Society for Research in Child Development, Vol. II, No. 5, 1937. Washington, D. C. Pp. 1-253.*

over a ten-year or longer period were selected.[3] Curves were drawn for each individual child on large cross-section paper and the figures read at half-year intervals from the graphs, i.e., the figures for each measurement were read at the 4½ year intersection, 5½ year intersection, and so on. This was to correct for the fact that the actual measurements were sometimes taken a month or two away from the half-year point. This also corrected for the fact that an occasional yearly examination was missed. However, the longitudinal series selected are very complete. The means and standard deviations were then calculated for each year level. The results of both methods of analysis are presented in two charts for the upper arches of boys and girls, respectively. In these figures the solid line represents the means obtained on the basis of the selected cases in which the longitudinal measurements were complete and the dotted line represents the means obtained by averaging all the cases available at any particular year level.

These figures cover five measurements: 3-3 representing width of the arch from the tip of the cuspid on one side to the tip of the cuspid on the opposite side of the arch; 4-4 representing width from the tip of the lingual cusp on the first deciduous molar on one side to that on the opposite side; 5-5 representing width from the tip of the mesio-lingual cusp of the second deciduous molar on one side of the mouth to that on the opposite side; and 6-6 measurement representing width from the tip of the mesio-lingual cusp of the first permanent molar on one side to that on the opposite side of the same arch. The 3-5 measurement was taken from the mesial point of the cuspid at the gingival to the most distal point of the second deciduous molar at the gingival of the same side of the arch. After the normal loss of the deciduous teeth, the corresponding points on the permanent teeth were used in the measurements. All measurements are expressed in millimeters. They were made by three experienced persons who independently measured the casts for each child at each age level. The mean of these three measurements gives the figure at each age level for each child, which when averaged becomes the basis for the material presented in this paper.

From the inspection of the figures, it is clear that the selected longitudinal data give very clean and consistent curves in comparison with the results obtained when all the cases are included and no account is taken of differential selection from the total population at different age levels. Thus the 5-5 line in Figure 1 shows a marked divergence below at the 8.6 level and a divergence above at the 9.6 and 12.6 levels. The 3-5 curve in Figure 1 is particularly erratic at the upper age levels. For Figure 2 there are likewise striking irregularities in the curves from the cross-section data. In order to show the effect upon the dispersion, Table 2 presents the standard deviations for both boys and girls for the 5-5 series of measurements.

The effect is not, however, quite so marked as it is upon the means, shown in the 5-5 curves in Figures 1 and 2. For the boys 6 of the standard deviations for the whole group are larger than those for the selected group, while 5 are lower. For the girls 4 are larger for the whole group and 7 are larger for the selected group. But from year to year the standard deviations are more consistent for the selected group. For the boys a trend toward a steady increase is apparent in the selected group, but is not quite so clear in the whole group; for the girls this trend is not quite so clear, but is again more evident in the selected group than in the whole group.

It is clear that more meaningful and consistent data are obtained from the smaller but complete longitudinal series than from the whole mass of data. There

[3] *The discrepancy between the number of cases in Table 1 at the 12.6 and 13.6 year level and the cases in the selected groups is explained in terms of the fact that more interpolation was necessary at these levels and that for certain cases in the selected group measurements were available at high age levels. This, however, does not affect the results from 3.6 years to 11.6 years, i.e., the main body of data.*

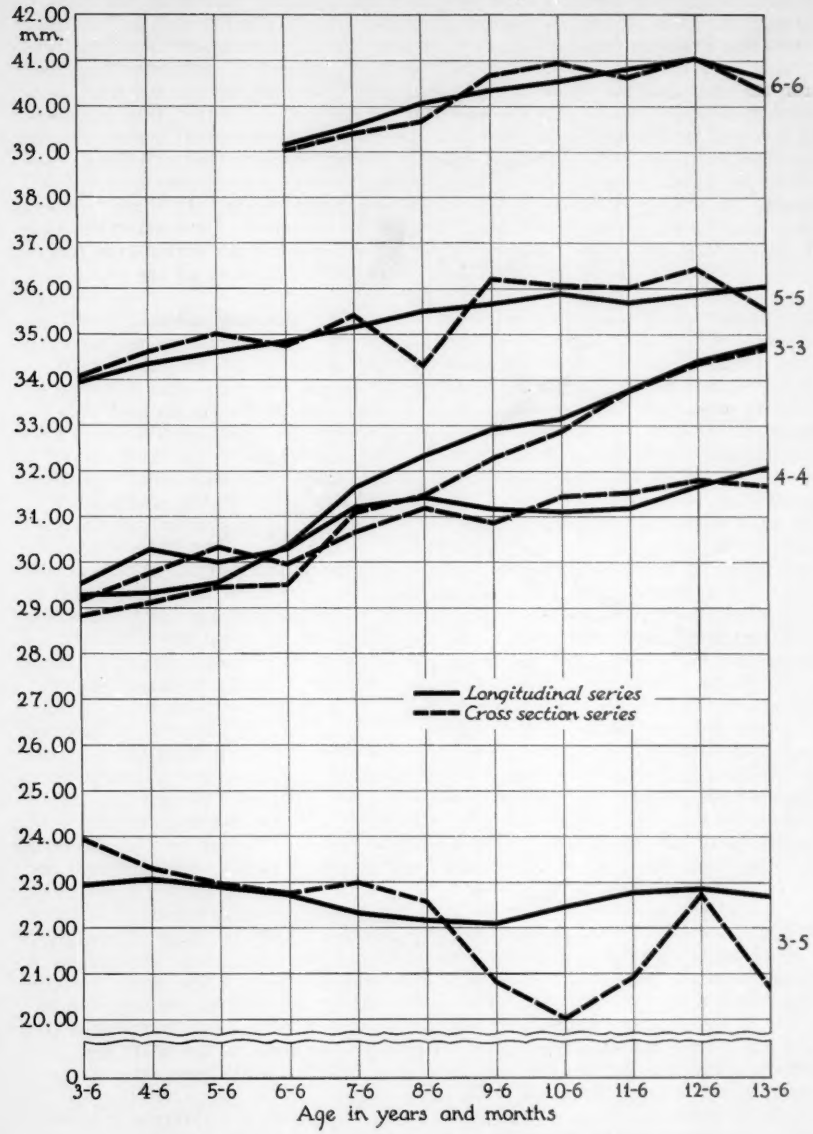


Fig. 1. Measurements of Boys' Upper Dental Arches

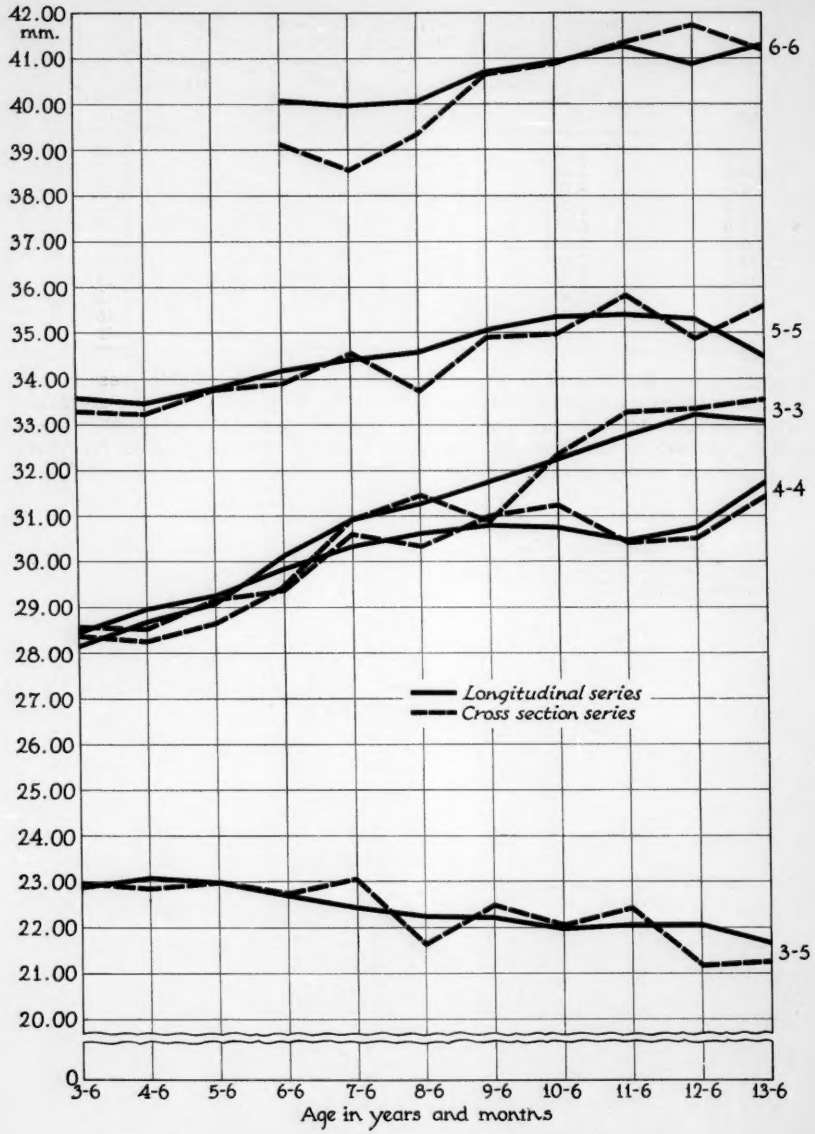


Fig. 2. Measurements of Girls' Upper Dental Arches

TABLE 2

COMPARISON STANDARD DEVIATIONS FOR 5-5 UPPERS FOR SELECTED LONGITUDINAL SERIES WITH ALL DATA

| Age | Boys | | Girls | |
|---|---|---|---|---|
| | Whole S.D. | Selected S.D. | Whole S.D. | Selected S.D. |
| 3-6 | 1.98 | 1.52 | 1.44 | 2.46 |
| 4-6 | 1.44 | 1.74 | 2.06 | 2.23 |
| 5-6 | 2.00 | 1.95 | 2.02 | 2.03 |
| 6-6 | 2.01 | 1.98 | 1.91 | 2.02 |
| 7-6 | 2.31 | 2.07 | 2.74 | 2.13 |
| 8-6 | 2.21 | 2.03 | 2.76 | 2.23 |
| 9-6 | 2.14 | 2.20 | 2.94 | 2.41 |
| 10-6 | 2.56 | 2.46 | 2.09 | 2.49 |
| 11-6 | 2.67 | 2.68 | 2.31 | 2.41 |
| 12-6 | 2.70 | 2.72 | 2.20 | 2.46 |
| 13-6 | 2.68 | 2.76 | 2.92 | 2.24 |

are, then, decided advantages in retaining for tabular and graphic presentation and for statistical analysis only those cases for which complete data are available. The additional data, resulting from the use of partial or incomplete series, instead of adding to the significance of the results actually function to distort or render unintelligible underlying trends.